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ABSTRACT

This document addresses the use of technology to enrich education. Twelve papers discuss research programs and perspectives and methods of research in technology and teacher education. Titles are: "Research Methods and Paradigms in Technology and Teacher Education" (Hersholt C. Waxman and George W. Bright); "Past and Future Stages in Educational Computing Research" (Cleborne D. Maddux); "Contexts for Research on Technology and Teacher Education" (Richard T. Johnson); "Technology and Teacher Education: A Research Development Agenda" (Jerry Willis); "A Systems Integration Approach to Researching the Role of Technology in Professional Development" (Douglas Brooks); "Current Research in Technology and Teacher Education: Three Phases of Our Mission" (D. LaMont Johnson and Steven D. Harlow); "Experimental and Quasi-Experimental Research in Technology and Teacher Education" (Kip Tellez); "Survey Research and Content Analysis Research in Technology and Teacher Education" (Greg Brownell); "Meta-Analysis in Technology" (Yuen-Kuang Liao and George W. Bright); "Ethnographic Research in Technology and Teacher Education" (Dianne Novak-Aitken); "Systematic Classroom Observations of Technology Use" (Juanita V. Copley and Susan E. Williams); "The Future of Research on Technology and Teacher Education" (George W. Bright and Hersholt C. Waxman). References are provided after each paper. (AEF)

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Approaches to Research on Teacher Education and Technology

Edited by
Hersholt C. Waxman
and
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Society for Technology and Teacher Education

Monograph Series General Editors

Cleborne D. Maddux and Michael D. Wiggongr

ASSOCIATION FOR THE ADVANCEMENT OF COMPUTING IN EDUCATION

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on
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Hersholt C. Waxman and George W. Bright, Editors

Cleborne D. Maddux and Michael D. Waggoner
Monograph Series General Editors

Society for Technology and Teacher Education
Monograph Series No. 1



ASSOCIATION FOR THE ADVANCEMENT OF COMPUTING IN EDUCATION
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Preface

It is with great pleasure that we present the first of what we hope will be a long series of monographs by the Society for Technology and Teacher Education (STATE) and published by the Association for the Advancement of Computing in Education. Readers will note that this first monograph addresses a number of topics of importance to those of us who believe that technology can enrich and improve education. Future volumes in this series will probably be more specialized. The present, more general plan seemed appropriate for the initial publication of our organization, since it provides exposure for a number of authors writing about a variety of issues. We believe the monograph does an excellent job of identifying alternative concerns and goals, and will be useful as we begin to define the character and focus of the Society for Technology and Teacher Education.

The purpose of this monograph series is to provide a forum for manuscripts that are too long or too specialized for publication in traditional scholarly outlets, such as journals. Those interested in proposing future volumes should submit, in triplicate, a title and a 2-3 page narrative summarizing the content. The narrative should include proposed sections or chapters, selected references, and vitae for contributing authors (if more than one). The proposal should also include an estimate of the length of the proposed monograph and a deadline for completion of the manuscript. *Proposals should be mailed to:* Cleborne D. Maddux, College of Education, University of Nevada, Reno, NV, 89557-0029, USA.

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Research Methods and Paradigms in Technology and Teacher Education

Hersholt C. Waxman and George W. Bright

The unintended damage of conclusions and action based on questionable research designs and the inappropriate use of analytic methods is incalculable (Pedhauzer, 1982, p. 264).

Nearly a decade ago, one of the major concerns among teacher educators was that practices were often based on unexamined assumptions with little empirical data supporting what was done in teacher education (Howey, 1977; Tabachnick, Popkewitz, & Zeichner, 1980; Waxman & Walberg, 1986). Furthermore, a number of criticisms about the quality and quantity of research on teacher education were made by reviewers in the mainstream, as well as those outside the field (Ashton & Crocker, 1987; Cruickshank, 1984; Lanier & Little, 1986; Waxman & Walberg, 1986). Some educators even argued that the lack of a body of research knowledge in teacher education was one of the major obstacles that prevented us from changing or improving teacher education (Lanier & Little, 1986).

Now, nearly a decade later, we have seen considerable progress in the field, and teacher educators have become both producers and consumers of educational research (Doyle, 1990). Recently, for example, there have been several comprehensive books that have reviewed and summarized research in the field (e.g., Dunkin, 1987; Houston, 1990; Reynolds, 1989). Within teacher education, the role and influence of

technology on teacher and student outcomes has been one of the areas that has begun to be extensively researched in the past decade. This monograph commissioned by the Society for Technology and Teacher Education, a new division of the Association for the Advancement of Computing in Education, highlights some of the recent work of researchers in the field of technology and teacher education. More specifically, this monograph examines typical research approaches and methods that have been used in the field as well as paradigms or conceptualizations of research in technology and teacher education.

There are many books and articles that have focused on general research methods in education (e.g., Borg & Gall, 1989; Jaeger, 1988; Keeves, 1988). Similarly, there are a variety of articles and books that have summarized research paradigms in areas such as teaching and teacher education (e.g., Bellack, 1981; Clark, 1979; Doyle, 1977, 1990; Fenstermacher, 1978; Shulman, 1986; Waxman & Walberg, 1991; Yarger & Smith, 1990; Zeichner, 1983). Likewise, there have been several articles written on research paradigms and methods in computing research (e.g., Heid, 1990; Williams & Brown, 1989). There has not, however, been very much written specifically on research methods and paradigms in technology and teacher education. Examining research methods and paradigms in technology and teacher education is important because in educational research, the answers we develop are shaped by the (a) form of questions we ask and (b) methods we use to resolve them (Clark, 1979). Unfortunately, investigators' personal commitments to a given research methodology have sometimes guided and shaped the research process by affecting their choice of design, instrumentation, and interpretation of data (Dunkin & Biddle, 1974). In other words, the selection of the research method is often related to the theoretical or ideological commitments or beliefs of the investigator (Shulman, 1981). As Kaplan (1963) puts it, "it comes as no particular surprise to discover that a scientist formulates problems in a way which requires for their solution just those techniques in which he himself is specially skilled" (p. 28). Awareness of a variety of research methodologies and paradigms can broaden our approach and perspective on research problems and change our ways of thinking about what we can study and how we can study it (Kerlinger, 1977).

The primary objective of this monograph is to make educators and researchers aware of the "full rich variety of methods that comprise the family of disciplined inquiry in educational research" (Shulman, 1981, p. 12), and especially the field of research in technology and teacher education. The most effective programs of educational research reflect intelligent deployment of a diversity of research methods applied to their appropriate research questions (Shulman, 1981, 1986). Since effective researchers must be able to combine methodological competence

with substantive knowledge, the other major focus of this monograph is to provide educators with an overview of the variety of research problems and topics in technology and teacher education. Although the specific substantive knowledge base of this discipline can be found in several other sources (e.g., Carey, Carey, Willis, & Willis, 1991, 1992), there is still a need to continually focus on educational theories, issues, and problems related to research. As Pedhauzer (1975) puts it, "methods per se mean little unless they are integrated within a theoretical context and are used to test hypotheses derived from theory" (p. 243). He similarly adds that "statistical results may be meaningful only when they are obtained in a research design developed within a sound theoretical context" (p. 264). In other words, although this monograph focuses on research methods, we cannot ignore the importance of being knowledgeable about educational theory and prior research in the field.

We also cannot ignore, however, the fact that technology itself may cause us to change the ways we view the world. In mathematics, for example, the nature of mathematical inquiry has been fundamentally altered by the tools that technology provides. Perhaps the best example of this is the fact that the famous "four-color" problem was first solved on a computer. The techniques used in the proof of that theorem could not have been carried out without the computational power of that machine. At a somewhat more mundane level, statistical analysis techniques are now being developed that rely on the interaction between machines (primarily, computer graphics programs) and users. The software allows people to "visualize" data and to make modifications in the manipulations of those data based on the images that are generated.

It is not unreasonable to expect that technology will also fundamentally change the nature of instruction, and consequently, the nature of teacher education. A large component of instruction involves interactions among students, teachers, and information. Technology alters the nature of those interactions because it alters the ways that information can be obtained, manipulated, and displayed. Teachers and students will certainly have to learn how to deal with these new types of interactions, but equally important, teacher educators will also have to learn to cope. It is this process of change among teachers and teacher educators that is most directly the focus of research on technology and teacher education.

Research Methods and Paradigms

A research methodology is a specific technique or strategy of inquiry, while a research paradigm is a matrix of beliefs and assumptions about the nature and purpose of a phenomenon that gives shape

to specific forms of inquiry (Zeichner, 1983). As Padilla (1990) describes it, "a scientific 'paradigm' orients and guides the thinking about researchable problems, theory, methods, and interpretation of data" (p. 18). A paradigm is an accepted and shared model of research where the same rules and standards are applied (Kuhn, 1970). It is a way of conceptualizing research that represents the perspective of the researcher toward the problems being studied. According to Reichardt and Cook (1979), "a paradigm includes not only a philosophical world view but also a linkage to a certain type of research method" (p. 11). Consequently, the paradigm determines the research methodology. This monograph's dual emphasis on methodologies and paradigms allows educators to understand how theoretical considerations determine the appropriate analytic tools that should be used in research in technology and teacher education.

We do not know at this time how technologies might influence the future development of research methodologies or paradigms for the study of teacher education in general or technology and teacher education in particular. It is certainly possible that there will be critical and deep changes in the ways we think about teacher education research. We hope that this monograph will move the discussion of these issues forward so that future research is significantly more valuable than it is today.

Overview of the Monograph

This monograph is divided into two parts. Part I, *Overviews of Research Programs and Perspectives*, addresses several specific frameworks and approaches for research on technology and teacher education. Although the chapters in this part are quite diverse, they draw together some of the potential directions for research in technology and teacher education. In the first chapter, Cleborne Maddux describes past and future research stages in educational computing and argues that research now needs to ask which and how learner and learning variables interact with teaching variables as they relate to specific dependent variables. In the next chapter, Richard Johnson reviews recent research findings that address technological media and how its implementation into educational contexts affects student learning outcomes. Jerry Willis follows with a proposal for teacher educators in the area of technology to change their research focus from a Research-to-Support-Theory Model to an Instructional Development Research Model. Next, Douglas Brooks proposes a systems integration approach for researching the role of technology in professional development. In the last chapter of Part I, LaMont Johnson and Steven Harlow describe some current research in technology and teacher education and argue that there are three phases

of our mission, (a) acquiring and developing technology, (b) integrating technology, and (c) engaging active conversation with public school practice.

Part II, *Methods of Research in Technology and Teacher Education*, focuses on specific research methods and on how they have been used in technology and teacher education. Although the chapters in this part do not review all of the potential methods for conducting research in technology and teacher education, they do represent most of the methods that are generally used in this area. In the first chapter, Kip Tellez describes experimental and quasi-experimental research in technology and teacher education and argues that there should be more quality experimental research in this area. In the next chapter, Gregg Brownell summarizes two types of descriptive research: (a) survey research and (b) content analysis research. He outlines the concepts, techniques, and provides examples for each type of research. Yuen-Kuang Liao and George Bright describe the meta-analytic research method and focus on the types of research questions that might be addressed by using that method in technology and teacher education. Dianne Novak provides an overview of qualitative research methods and describes features of ethnographic research. She also provides a specific example from a study that illustrates how ethnographic research can inform teacher education. In the last chapter of Part II, Juanita Copley and Susan Williams describe the use of systematic classroom observation in technology and teacher education research and argue that its use needs to be expanded in this area.

In the final summary chapter, *The Future of Research on Technology and Teacher Education*, some of the future research trends and directions in technology and teacher education are discussed. In particular, Bright and Waxman suggest that there are three ways technology can be used: (a) to teach teachers about technology, (b) to improve the delivery of current teacher education programs, and (c) to restructure teacher education. They argue, however, that the use of technology to restructure or change teacher education should be the most important focus. They also discuss some methodological advances and how improvement in analytic techniques can also change research in the field.

Improving the Research in Technology and Teacher Education

This monograph illustrates ways we can use research to improve the effects of technology on teaching and teacher education. The purpose of this monograph is to make available information for improving our understanding of the problems as well as solutions to problems related to research in technology and teacher education. As Walker (1992) puts it, "these are interesting times for anyone concerned with the methodology of research in education" (p. 98). He further adds that

the old order based on an empirical-scientific-positivist doctrine has lost its grip on the field, and no new doctrine has yet achieved dominance, so the educational researcher planning a study today faces an open field bright with possibilities. (p. 98)

Given the large number of appropriate methodological options that researchers have in designing their studies, we may now start to see more and better research in technology that contributes to educational improvements.

Research currently has a major impact on all aspects of education, including that of technology and teacher education (Waetjen, 1991). We maintain that research can play a critical role in improving the role of technology in teacher education. Although recognition of the uniqueness of each teacher education program, school, and classroom situation will always need to be considered, the accumulation of research evidence over time and across studies may provide consistent findings that enhance our understandings of the role of technology and teacher education. In other words, more and better research in this field may allow us to change and improve the education of teachers and consequently improve the education of students.

The general public and policymakers have often not had confidence in the research findings of educational researchers because of the contradictory conclusions often presented by different studies using different analytic methods or research methods. Although research syntheses and meta-analyses have alleviated some of these concerns, researchers must still explain the advantages, disadvantages, and appropriate uses of the methodology they employ. Only then, will educators begin to understand the complicated role that methodology has in educational research. We hope at the same time that policy makers will continue to acknowledge the contribution that education research can have in formulating policies that effectively support improvements in schools, classrooms, and teacher education programs. Research is a vehicle that can enhance educational change, but we must be aware that in order to impact practice, research must be effectively communicated and disseminated.

Improving the research on technology and teacher education, however, will take more than just awareness of the problems and knowledge of some solutions. Methodological rigor and sophistication are only one component of excellence in education (Walker, 1992). We will also need a commitment towards quality research and a call to action for collaboration among educators who have different paradigms or perspectives about research in the field. A broad, interdisciplinary research agenda will need to be collaboratively developed and then carried out vigorously. It will need to include both basic and applied research as well as long-term and short-term programs. This process will also require a

change in attitudes that will make us all aware of the severity of the problems associated with faulty research and seriously committed to improving the research in technology and teacher education. This monograph is intended to be a step in that direction.

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Past and Future Stages in Educational Computing Research

Cleborne D. Maddux

It almost goes without saying that research is an important component of any academic discipline. It is particularly important in all areas of educational technology since the field in general, and educational computing in particular, seems especially vulnerable to being driven by new products.

An interesting indication of the influence of the marketplace can be seen by examining the covers of educational computing magazines over the last few years. This is revealing because the covers of such magazines, and the lead stories they represent, very frequently deal with new hardware and are often blatant examples of media "hype."

The best recent example of this phenomenon occurred a few years ago when Apple introduced the IIGS computer which was featured on the covers of practically every computer magazine in the country, including those that deal primarily with educational computing. (The hype over the Apple IIGS seems especially ironic today in light of the fact that Apple has, in effect, abandoned the IIGS by its decision to make the new Mac computer Apple II, but not Apple IIGS compatible.)

The latest media-proclaimed panacea seems to be *Windows 3.0*, which, like the IIGS, is gracing the covers of most of the current computer and educational computer magazines. A good example of this is the March, 1991 issue of a popular computer magazine for teachers. This cover prominently advertises a story on *Windows 3.0* and its role in education. However, in this three-page article, there is not a single

reason given for why educators in particular need *Windows 3.0*, or how it might be used advantageously in education. In fact, about the only factual material comes at the end when the author states that *Windows 3.0* or future versions will probably not run on machines now owned by schools, but may work on future machines. Despite this considerable problem, the author concludes by pronouncing programs like *Windows 3.0* "the wave of the future."

Perhaps such programs are the wave of the future, but should they be? Isn't that the question that educational publications should pose and attempt to answer for educators?

Actually, there is no evidence that I am aware of that a graphical interface has unique educational value. In fact, there is no evidence that such interfaces are any easier for children or adults to learn or to use than are traditional command-oriented operating systems. (I know what Mac enthusiasts say, and I know how MS-DOS enthusiasts react, but I learned long ago that a particular computer or operating system is a little like hometowns: Everyone who has one can provide a testimonial about even the most dreadful example.) Perhaps graphical interfaces do have great educational value. However, until that is established by something a bit more substantial than blind faith, educational authors should refrain from proclaiming them "the wave of the future."

It seems incredible, but I have never seen any serious theoretical discussion of whether graphical interfaces are consistent (or inconsistent) with what we know about the way children think or learn, or whether pointing and clicking a mouse on icons has any concrete advantages over typing word commands. There is probably no absolute answer to the question of whether graphical interfaces are superior to text-oriented operating systems. I suspect that if there are differences in educational efficacy, they are weak and interact with developmental stage, previous computer experience, intelligence, computing task to be accomplished, and a host of other unknown and potentially confounding variables.

The point is that new hardware, no matter how technically advanced, is not educational news, and software is educational news only if it is potentially useful in education. *Windows 3.0* is certainly new software, but I am not convinced that it has educational value or potential. Even if it does, I would prefer to find, in our professional literature, discussion and testing of ideas, (learning theories and teaching methods) rather than a focus on hardware or software. An emphasis on the technology for its own sake may be appropriate for publications aimed at hobbyists, but is inappropriate in educational literature. In my view, many contemporary writers of books and articles about educational computing have grossly neglected debating ways educators should and should not be using technology, while they have devoted far

too much space to questions about what we can and cannot do in a strictly technical sense.

Teachers frequently ask me technical questions that begin with the words "Is it possible to . . . ?" Although I always do my best to answer as completely as possible, I do not find such questions to be very interesting. After all, the answer is almost invariably the same—it is possible to do almost anything one can imagine with technology in general, and with computers in particular, although it is frequently not possible to do so with what most teachers would consider a reasonable investment in time, effort, expertise, or money.

Far more interesting and important, yet far less frequently asked questions begin with the words "Do you think we should . . . ?" These are questions that are truly educational in nature. They are important educational questions for a number of reasons, not least of which is that they force us to speculate about appropriate and inappropriate relationships between humans and their machines, and consequently help us begin to make value judgments about our work with children and with colleagues.

Actually, there is an appropriate time for educators to discuss strictly technical questions. I believe that time is *after* we have concluded that either the process used or the product produced by the technology in question has educational value or potential. Even then, however, we should require authors of articles in educational publications to provide concrete evidence, or at the least, convincing theoretical justification, in support of statements that a specific piece of hardware or software is "the wave of the future."

The Role of Research

Research can and should be the most effective factor in reducing the tendency for the field to be driven by new products and related media hype. Research helps us decide what kinds of educational problems should be submitted to computer solutions by providing information about how specific computer applications work under varying educational conditions. (This is not to imply that research can provide *all* the answers, however. At least equally important is consideration of the ethical questions related to computing.)

Because the field of educational computing is so new, it does not have a substantial research base. However, there has been remarkable improvement of late in both the quantity and quality of educational computing research. Currently, we have some important knowledge about the use of computing in education, and we are continually learning more.

In the remainder of this paper, I will discuss research strategies and findings in the new discipline of educational computing. I will first

attempt to condense the results of all such research into one very important, general finding and will then discuss past computing research and attempt to categorize it into three roughly chronological, but overlapping stages. (This paper will deal with educational computing research during the current cycle of interest beginning in the late 1970s and continuing to the present time and will not deal with earlier periods such as the late 1950s and 1960s.) I will then attempt to be much more specific and detailed, and I will suggest research strategies and topics I believe are needed in the future.

What We Have Learned From Research in Educational Computing

It seems to me that the one irrefutable fact that is consistently verified by research in all three historical stages is that for the vast majority of children, there is no automatic educational value in mere exposure to computers. To put it even more simply, *nothing miraculous happens automatically as a result of putting a child and a computer in the same room*. That should not surprise us at all, since most of us recognize that the same is true of a child and a book, a child and a television set, or even a child and a teacher.

This finding might seem nothing more than common sense. However, during Stage One, practicing teachers and researchers alike behaved almost as if they believed that exposure to computers was all that was necessary.

Stage One

In Stage One, the first wave of educational computer applications were based on the idea that exposure to computers would produce general educational benefits. During this time, literature in the field was research only in its broadest sense. In fact, experimental research was rare and professional journals were dominated by position papers and personal testimonials. A few reports of needs assessments and attitude surveys also appeared.

It was during Stage One that the computer literacy movement reached its peak, and experts talked about how important it was for children to be "familiar" with computers. Because software was scarce and expensive, there was often little that could be done with computers in schools other than write BASIC programs. Therefore, "familiarity" often meant teaching children BASIC programming.

Surveys conducted during this stage also revealed the emphasis on exposure. Such surveys showed that school administrators almost unanimously identified equipment scarcity as the number one problem

in educational computing, and articles published during this time period often stated or implied that if we could only place "enough" computers into public schools, computer education would, almost inevitably, produce great teaching and learning benefits.

The emphasis on equipment scarcity served an important purpose during Stage One. Machines were scarce, and there is obviously some unknown but nevertheless critical, minimal number of machines that must be in schools before even exemplary use can be expected to have a positive effect on teaching and learning. Stage One literature called attention to this important problem. Although it was necessary at the time, this early emphasis on equipment probably accounts for some of the present inappropriate technical emphasis. Of course, many schools are still experiencing hardware scarcity problems, and it is difficult to imagine a time when all schools will have enough high-quality hardware and software. However, if we are to progress as a discipline, I believe it is time to expand our concerns to include pedagogical, as well as equipment problems.

Toward the end of Stage One, most educators began to realize that the computer literacy movement was ill-advised, partly because the two arguments used to justify it were flawed. One argument had been that children needed to know how to program computers in order to get and keep a good job. The other was that we, as a nation, were falling behind in technology, and that programming skills were part of the scientific education needed to bolster our faltering economic health.

However, we soon realized that these arguments were illogical. There are only about 20,000 programming jobs in the country, an obviously insufficient number to justify moving 40,000,000 school children through a curriculum emphasizing programming skills. Then too, it became apparent that as computers become more and more sophisticated, the typical on-the-job user needs to know less and less, rather than more and more about them. In addition, it is questionable that the US is falling behind in technology. In fact, most inventions continue to come from the US, and foreign students flock to this country's universities to complete scientific and engineering degrees. In fact, business leaders and others point out that our economic leadership is faltering not because American companies are using outdated or flawed technology, but because of our inability to compete with Japan and other nations in the marketing of new developments (many of which are researched and developed in the US). Other causes for our economic problems include over-reliance on foreign oil, poor business and management decisions, and labor problems, rather than a failure to master technology. (For an excellent discussion of the literacy movement and its flawed logic, see Kelman, 1984).

Stage Two

During Stage Two, a slightly more sophisticated approach was taken to computer education. During this stage, the rationale was that while mere exposure to computers might not produce general educational benefits (Stage One assumptions), exposure to some particular computer application would produce specific educational gains. The focus moved away from general exposure, and toward exposure to a variety of specific applications.

Research during this stage also became more sophisticated. Typical research methodology made use of experimental and control groups, with children in the experimental groups using the computer application in question, while children in the control group did not. After a period of time (often unreasonably short), a variety of dependent variables were checked for improvement.

Although this research strategy represented an improvement over that found in the typical Stage One study, designs were still simplistic. Exposure was still being emphasized, since there was little if any attention given to learner variables, or to teaching variables. To illustrate, research hypotheses tended to resemble the following:

IF LEARNERS (AT ANY LEVEL, ANY AGE, ANY GENDER, ANY GRADE, ANY IQ, ETC.) ARE TAUGHT [some computer application] (FOR ANY LENGTH OF TIME, USING ANY METHOD, BY ANY TEACHER, ETC.), THEY WILL IMPROVE MORE IN [some cognitive or performance variable] THAN AN EXPERIMENTAL GROUP WHO ARE TAUGHT TRADITIONALLY [whatever that is].

Research and practice related to computer programming and problem solving provides an excellent example of Stage One and Stage Two thinking and practice. As I have pointed out, during Stage One, programming was taught as the route to computer literacy and general educational, vocational, and societal benefits. During Stage Two, the emphasis switched to programming (most frequently using the Logo language) as a vehicle to improve cognitive skills such as general problem solving.

Few could deny that this shift in thinking represented progress. However, typical of Stage Two thinking, many educators proceeded as if they believed that all we had to do was teach a child to program computers without regard to teaching and learning variables, and the child would automatically be a better general problem solver than children who were not taught programming.

The series of research studies by Pea (1983) and Pea and Kurland (1983a, 1983b, 1983c, 1984) are examples of research in this mode. These

researchers compared problem-solving abilities of children who were taught to program using the Logo computer language with a control group of students who did not study Logo. They concluded that learning to program in Logo does not improve problem-solving skills.

In my view, however, no valid conclusions can be drawn from this research. The major problem with the study is that the researchers ignored both teaching and learning variables. For example, by the researchers' own admission, the Logo group did not master Logo. Therefore, many critics have asked what this research proves. After all, if the Logo group did not master Logo, what significance is there in the finding that this group (of nonprogrammers) ended the study no better at problem solving than the control group (also nonprogrammers)? Perhaps we could legitimately conclude that if teachers fail in their efforts to teach Logo programming, their students will be no better at problem solving than students who receive no Logo instruction! In other words, we learn that there is no value to mere exposure to computers.

What should these researchers have done? First, they should have focused on learner variables by testing the Logo group at the end of instruction, then selecting only those students who demonstrated programming mastery. They could then have compared the problem solving scores of these students (proficient programmers), with scores of those in the control group as well as with scores of students who did not achieve programming mastery. They might also have focused on teaching by blocking on this variable and using several different methods of teaching Logo. (Some research at the time was already beginning to hint that the discovery method of teaching, at least as it was often operationalized, did not result in programming mastery.)

Another problem with this research is an error that is not unique to computer education, but which pervades much educational research. Many educational researchers and consumers of educational research seem unaware that a scientific experiment can provide support for a hypothesis, or fail to provide support, but is not capable of disproving a hypothesis. At first glance, this may seem to be hair-splitting, but the distinction is central to the philosophy of science and scientific experimentation.

A hypothetical example from astronomy may help to clarify this point and illustrate why positive results are infinitely more significant and persuasive than are negative results. Let us suppose that an astronomer hypothesizes that there is an undiscovered tenth planet in our solar system. After exhaustive calculations, the astronomer designs a research study and trains a powerful telescope on the spot in the sky where he or she believes the planet exists. If the planet is seen, this lends extremely powerful support to the original hypothesis (although the results must still be replicated by other astronomers before it will be

regarded as fact). If, however, nothing is seen at that place in the sky, the hypothesis of a tenth planet is not disproved, although it would be correct to say that the study failed to provide support for the hypothesis.

Seeing the planet at the predicted spot is thus far more substantive than not seeing it. After all, if the planet is not seen, there are many possible explanations other than the nonexistence of the planet. For example, a tenth planet may exist but be at some spot other than that examined, the planet may be at the spot examined but the telescope may not be powerful enough to detect it, the astronomer may have made an error in calculation, etc.

It is popular (and accurate) to assert that the research on Logo is mixed and contradictory. I believe that one reason for this ambiguity is that so many researchers partly or completely ignore learning and teaching variables and interactions. When research studies are selected on the basis of quality, much of the ambiguity disappears. Such research provides substantial evidence that Logo, when taught to certain students, using specific methods, can result in improved problem-solving skills.

Some evidence for this comes from Roblyer, Castine, and King's (1988) meta-analysis. These reviewers selected fourteen studies that conformed to certain methodological and conceptual good practices, and concluded that these studies showed that Logo did improve problem solving skills. The better research that made this meta-analysis possible may represent the beginning of Stage Three.

Stage Three

We are presently at the beginning of this stage, and we seem to be changing our research questions from (a) asking whether exposure to computers in general has global educational benefits (Stage One), and (b) asking whether learning to use a specific application improves some cognitive or performance task regardless of who is taught and how they are taught (Stage Two), to (c) asking which and how learner and learning variables interact with teaching variables as they relate to specific dependent variables (Stage Three).

Some examples of Stage Three research topics follow, along with some comments: (These are intended to be illustrative only, and are not exhaustive nor presented in any particular order of importance.)

1. How successful are students at mastering Logo at different ages and ability levels using discovery teaching methods? In other words, we should seek to determine how learner variables interact with teaching methods as they relate to Logo mastery.

2. How do different teaching methodologies compare in effectiveness when applied to the turtle graphics parts of the language and when applied to the list processing parts?

3. What kinds of misunderstandings are common to learning disabled and non-learning disabled students when structured vs. discovery teaching is employed?

4. There is also the question of whether teaching programming can result in improved problem-solving skills that will transfer to other problem domains. We know that transfer is not automatic, and we now have some clues about how to facilitate transfer. We know, for example, that we need to continually point out how Logo problems and solutions are similar to problems and solutions in the problem domain in which we wish to achieve transfer. An important question is: What are the best ways to do this with varying types of students and for transfer to varying problem domains?

The above Stage Three sample questions share one characteristic: They all concentrate on learner/treatment interactions.

Research and practice in word processing and writing skills is another case in point. Until recently, many educators assumed that all we had to do was teach a student to do word processing and his or her writing would automatically improve. Our research designs, like the ones concerned with Logo and problem solving, reflected that naive idea. Because of this, many Stage Two writing studies produced disappointing results. (One of the characteristics of many Stage Two research studies was their disappointing results—a characteristic that helped fuel the backlash against educational computing.)

The first group of studies looking at revision, for example, seemed to indicate that although more revision does go on when using word processing, the increased revisions tend to be surface revisions such as spelling and mechanical changes, while pencil and paper tends to foster more deep, or content-level changes (Barker, 1987; Daiute, 1986; MacArthur, 1988; Montague, 1990). However, in my view, the research in word processing was stuck in Stage Two even longer than was research on Logo. Recently, it has become apparent that the research on word processing and its effect on writing revision has been very poor, with little control over type of machine, type of writing program, amount of word processing instruction given subjects, and degree of expertise in word processing (Barker, 1987, p. 116). Hopefully, Stage Three research will rectify some of these problems.

The concern with identifying learner/treatment interactions is positive and new, and it appears that this will be the dominant characteristic of Stage Three research and practice. Research has already begun to move in this direction, and the better word processing research, like the

better Logo research, is beginning to produce some more encouraging results than did Stage Two studies.

The US Office of Technology Assessment (1988) reviewed recent research and concluded that both normal and learning disabled students who used the word processor as a supplement to writing instruction made significant gains in writing ability, compared to control groups of students who did not receive the computer-assisted intervention. Roblyer, et al. (1988) found similar results in their meta-analysis.

In addition, we know that word processing results in more student writing. This is an important finding in light of various studies that have found traditional public school teachers averaging as little as 3% of the school day in writing activities. Perhaps most significantly of all, we know that word processing tends to produce improved student attitudes toward writing.

Actually, what we know in general about the educational effects of word processing is nearly identical to what we know about the educational effects of Logo. That is, with word processing, with Logo, and with other educational computing applications, efficacy depends on how they are used rather than on their mere presence or absence in schools.

Research on Use of Technology with Teachers-in-Training

This paper has concentrated on research on the use of computers with school-age children. This research has obvious relevance for teacher education for three reasons. First, it will determine the technology-related content that teacher trainers will build into their future curricula. For example, if Logo is effective as a cognitive amplifier for public school students, then teacher educators must assure that teachers-in-training are themselves competent Logo programmers and that they have effective teaching techniques for working with students. Second, teacher trainers in colleges of education are responsible for training future researchers who will investigate all aspects of applications of technology in education. Therefore, an understanding of the state of the art in computing research is vital to education professors. Third, the research base, when restricted only to those studies investigating technology and its infusion into existing college of education classes, is extremely limited. In fact, it is research only in the broadest sense, and the few empirical studies that have been reported have not, as a group, progressed beyond Stage One methodologies. Therefore, an understanding of the stages of research reviewed in this paper may be of use in moving this more narrowly focused research more quickly into Stage Three and beyond.

Summary

This brings me back to my original summary of what we have learned about educational computing over the last decade or so: specifically, that there is no automatic educational value in mere exposure to computers. In retrospect, this principle may appear trivial, or self-evident. Perhaps that is a characteristic of the results of a body of scientific research. Indeed, a major function of research is to establish the "common sense" of a discipline, which will then probably appear self-evident to later scholars and researchers. In reality, our knowledge about computer education, like all scientific knowledge, has been time consuming and difficult to acquire. Now that it has been acquired, we must take care to use it to good advantage as a guide to program development and as a stimulus for future research. Perhaps most important of all, we must design future research projects to maximize our chances of producing new knowledge, and not succumb to the temptation to rely on outdated, simplistic Stage One or Stage Two designs, which can only rediscover what our efforts to date have already revealed.

I believe that Stage Three educational computing research has already begun, and must continue, to emphasize learning-treatment interactions. If this trend continues, as I believe it will, the decade of the nineties should prove to be as dynamic and exciting for computer educators as was the decade of the eighties.

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3

Contexts for Research on Technology and Teacher Education

Richard T. Johnson

While commenting about an educator he recently participated in a public debate with, Seymour Papert reflected:

He was angry about the difference between color on a computer screen and the watercolors used by children in "real painting." He felt that working on the computer screen had far worse effects than undermining artistic development: it fundamentally changed the child's relationship with reality. (1987, p. 30)

When reflecting on this, one cannot help but think of the power of the words, *it fundamentally changed the child's relationship with reality*. This notion of how a "child's relationship with reality is changed" speaks to the potential power of using technology for teaching/learning in classroom contexts.

Many types of technologies are influencing children's experiences in academic, home, and other cultural settings (Johnson, 1990c; Kozma, 1991; Salomon, Perkins, & Globerson, 1991). In fact, a wealth of empirical data suggests that new uses of technologies can have a powerful impact on students' abilities to recall and comprehend information. This paper reviews recent findings that address technological media and how its implementation into educational contexts affects student learning outcomes.

Much of what we know about the relationship between technology and learning has been documented by experimental research in various

educational settings (e.g., Forman & Pufall, 1988; Palumbo, 1990). The experimental research model has typically illustrated the relationship between the interaction of the learner(s) and the technology, and how that interaction effects some type of student outcome measure(s) (e.g., word processing, writing skills, math computation abilities, achievement, etc.). While this research has been valuable for assessing how and why educators should implement technology into classroom settings, little experimental research has been conducted related to how technology is implemented and used in teacher education settings.

This is especially problematic given what we know about how technology has entered into elementary and secondary educational settings (Bruder, 1989; Nelson, Andris, & Keefe, 1991; Norvak & Berger, 1991). If teacher educators remain witness to "first-hand" implementation of technology in pre- and inservice programs, research must assist in the ongoing articulation of curricular and program level technology implementation.

For instance, research of mastery learning in various university classrooms reveals how computer technology generates significant improvements in achievement, when compared to traditional lecture/discussion approaches (Liefeld & Herrmann, 1990). While these positive effects have been illustrated in different university settings (e.g., a communications department or a psychology department), educators should frame the results in relation to how they might effect curriculum and course delivery in teacher education programs.

Liefeld and Herrmann's (1990) study could be especially beneficial to teacher educators who are in programs that are "charged" with articulating research that assists pre- and inservice classroom teachers with their educational practices. Classroom implementation of technology has been documented to assist in various types of student learning. The following section reviews some of these findings to date.

Learning with Computers

Studies on computer technology conducted in classroom and laboratory settings suggest that computer-assisted instruction has the ability to facilitate students' abilities to spontaneously use relevant knowledge in new contexts (e.g., Bransford, Franks, Vye, & Sherwood, 1986; Brown, Bransford, Ferrara, & Campione, 1983). In general, the more powerful instructional conditions (i.e., considering transfer to school success) engage students in problem solving and decision making. Such activities help students understand the nature of the problems that various concepts and procedures were designed to solve, and hence enable them to understand the functional significance of new information (Bransford, 1984; Brown, 1986; Brown, et al., 1983).

Some of the research on computer technology emphasizes the notion of transfer and the relationship of language, reading, writing, and information seeking to solving problems that are often encountered in the "real" world (Johnson, 1990b; The Cognition and Technology Group, 1990). Research on instructional classroom applications supports technology as an effective curriculum medium for assisting students in learning important concepts and acquiring basic thinking and literacy skills related to success in school.

Recent studies corroborate these findings. For example, Zellermayer, Salomon, Globerson, and Givon (1991) revealed that when students are provided writing training with a computer program that allows for writing in a knowledge-transforming manner, writing quality and metacognitive abilities surrounding understanding their writing quality improve. Guddemi and Mills (1989) noted that when children are supported (through literacy training) in computer word processing activities, they are more likely to initiate story writing, and writing at the computer and literacy table increases. Other studies lend support to classroom implementation of word processing programs for increasing writing quality (Grandgenett, Lloyd, & Hill, 1990/91; Morton, Lindsay, & Roche, 1989).

Chang and Osguthorpe (1990) illustrated that when kindergarten-aged children are instructed on a picture-word processor, they are more successful readers and writers when compared to students who did not receive the instruction. Students who participate in computer-assisted instruction also exhibit a positive attitude about technology. In fact, experiences with technology affects people's views and perspectives in several ways (Franz & Papert, 1988; Nix, 1988).

For instance, Doran and Kalinowski's (1991) study revealed that when adults are tutored by children they are less anxious about this technology. Humphries and Silliman's (1989/90) research illustrated that when different groups are questioned on their views of computers, the following trends are witnessed: preschoolers prefer using computers for games in many subject areas; parents prefer that preschool children use computers mostly for practice drills; and early childhood education preservice teachers prefer that computers be used for delivering mathematics and reading content.

Learning in Audiovisual Contexts

Television

The research base on television has greatly influenced our understanding of how children process and acquire knowledge in audiovisual technological contexts. Recent research reveals that children are not as

"defenseless" as earlier behavioral research depicted them to be as they view television. Instead, children are viewed as cognitively active recipients of televised information, in that they cognitively process television material, and the viewed material is influenced by their comprehension schemas, plans, and intentions (Field & Anderson, 1985). Studies of this framework have focused on the overall context of television viewing sessions, taking into account the child's background knowledge base and the precise viewing situation (Luke, 1985; Rice & Wartella, 1981; Salomon, 1979). These researchers have systematically studied how recipients of television information use background knowledge to mediate the incoming televised information and also how viewing television mediates their experiences and understanding of the world (Luke, 1985).

Children's retention is higher for visually presented televised information when it is compared to aurally presented information (Meringoff, 1980; Pezdek, Lehrer, & Simon, 1984; Pezdek & Stevens, 1984). While this research demonstrates that children do process both audio and visual features of televised programs, the visual-superiority effect has been repeatedly indicated across many different types of television shows (including commercials, cartoons, dramatic shows, *Sesame Street*, and prosocial programs).

The interpretation of an indepth analysis of media prompted Salomon (1979) to share his assumption that one medium presentation is not necessarily superior to another. He suggested, instead, that specific task demands of each medium denote the superiority of that medium when compared with others. Salomon felt that while figural and spatial information are best conveyed via visual presentation, verbal comprehension, and logical reasoning are highlighted when conveyed with pure verbal presentation.

The positive findings from the extensive research base on television, warrants more empirical work on the different ways that classroom teachers use various media presentations to introduce and further teach academic content or "building blocks" necessary for later school success. It may well be that we are raising a culture of "television expert" children who are proficient visual memory story experts, but who are lacking story experience with other necessary media presentations (books, films, radio).

Video Technology

Video technology (videodisc and videocassette) has been shown by The Cognition and Technology Group at Vanderbilt University (1990), Johnson (1990a, 1990b) and others (Pea, 1990; Schwen, Goodrum, Knuth, & Dorsey, 1990; Walker de Felix, Johnson, & Schick, 1990) to

provide strong contextual support for acquiring knowledge. The Cognition and Technology Group (1990) argue that contextualizing knowledge acquisition has powerful effects on students' abilities to access and use that knowledge in the future. Their research illustrates how a videodisc instructional format is a rich context for teaching real-world problem solving. Vye, Rowe, Kinzer, and Risko, (1990) reveal that in these highly effective instructional formats, or "macrocontexts" for learning

the context is shared by all students because the context is sufficiently broad and rich to enable the teacher to integrate instruction across traditional curricular areas (i.e., to teach comprehension, writing, social studies and science using the same materials and in the same time frame). (p. 2)

The instruction therefore allows for what Brown, Collins, and Duiguid (1989) call "authentic" goals for learning designated content. This videodisc instructional context invites students to become engaged in the presented information so as to want to solve the problems posed. The Cognition and Technology Group (1990) refers to this notion of situated learning as anchored instruction, because the instruction is anchored in multimedia contexts created by the students and teacher.

In general, these "anchored instructional" conditions engage students in problem solving and decision making. Such activities help students understand the nature of the problems that various concepts and procedures were designed to solve, and hence enable them to understand the functional significance of new information. Under these conditions, when similar problems are encountered in subsequent situations, spontaneous use of relevant concepts and strategies is much more likely to occur.

Some members of the Learning Technology Center at Vanderbilt are applying these findings into research on teacher education. Goldman, Barron, and Witherspoon (1991) have conducted studies which reveal that "situating" or "anchoring" teacher education in case method context (delivered via hypermedia classroom settings) assists preservice teachers in their own learning and later teaching. Preservice teachers instructed in these contextualized classroom settings implement the ideas learned from the hypermedia context into their own teaching (Goldman et al., 1991; Goldman & Barron, 1990).

The application of this relatively new educational technology, (hypermedia) in teacher education, provides a unique way of linking many of the technologies discussed earlier (including computers, videodisc, audio, text, graphics and CD-ROM). Hypermedia provides the potential for creative, interactive uses of computers and supporting

video technology for teaching and learning contexts (Kozma, 1991; Nichol, 1989/90; Semper, 1990). Other researchers have also implemented innovative technology into their teacher education programs.

For instance, Durham and Sunal (1991) set up a communication network program to enhance the early childhood and elementary methods block of a teacher education program. This program set up electronic mail, a fax machine, and a computer communications network. The purpose of this system was to enhance instructor and student teacher communication during a preservice education program. Results of this study illustrated that experimental school teachers (those with all of the above-mentioned technology) increased their use of professional contacts via the technology.

Similarly, other studies reveal that the provision of the technology and comfort in using it enhances future use. Troutman's (1991) research provides a good example of this. She conducted a survey with 292 preservice teachers concerning their attitude toward personal and school computer use. Her findings revealed that preservice teachers who are comfortable using computers at home are more secure using computers in the school. Findings such as these are important as they lend support for teacher education programs providing many opportunities for preservice teachers to work with computers and other technologies.

Contextualizing Knowledge Acquisition

Research on thinking suggests that, in order to achieve the goal of helping students learn to think for themselves, we must focus simultaneously on general "metacognitive" processes of problem solving (e.g., Brown & Campione, 1987) and on well organized knowledge structures that provide conceptual tools for thinking (e.g., Bransford, Sherwood, Vye, & Rieser, 1986). Many educational technology programs focus either on the acquisition of specific sets of conceptual or procedural knowledge or on general strategies for problem solving.

As noted earlier, Johnson (1990a, 1990b) and others (Cognition and Technology Group, 1990; Goldman & Barron, 1990) worked with video-disc technology in part, because it illustrates problem solving. Nevertheless, none of them assume instruction that simply helps students learn particular stories or specific cases, will provide information that will spontaneously be used to solve problems. The context (presentation format, supporting software and hardware, graphics capabilities, etc.) must be semantically rich enough to assist in initial learning and for later transfer to occur.

Significance of Technology

"Educators have found in intelligent technologies the vision of a new kind of education that empowers and liberates the mind as no pattern of educational practice has done to date" (Salomon, et al., 1991, p. 2). Educational uses of various technologies can have a powerful impact on student learning. Many studies and their supporting data provide support for this claim.

Despite the tremendous potential of classroom implementation of learning technology, it also seems clear that mere availability of computers or images on a videodisc or videotape are not powerful in and of themselves. Simply informing or teaching preservice teachers how to use technology will not influence student outcomes. These technologies need to be creatively incorporated into classroom formats that help students develop powerful sets of knowledge and skills (Forman & Pufall, 1988; Hansen, 1990). Harrington (1991) suggests that teacher educators prepare preservice teachers for technological literacy by implementing three different objectives:

- (1) prepare students to use technology; (2) provide them with experiences that incorporate technology in such a way that the substantive goals of the program are supported; and (3) enable them to develop a critical perspective on the use of technology. (p. 51)

Perhaps replicating the goals of The Cognition and Technology Group (1990) would assist educational researchers in these endeavors. That research group is conducting ongoing series of descriptive and experimental studies that allows them to assess the "value added" of systematically elaborating various teaching-with-technology situations in ways that encourage students to think for themselves and to understand the value of knowledge for their own problem solving.

While the studies presented here are promising, they are by no means comprehensive. Much more research needs to be conducted, implementing multiple research methodologies (e.g., case studies, ethnographic, and other qualitative and quantitative types), as educators pursue unanswered questions about how to use this technology. For instance, questions might include: We know mastery learning in computer environments is beneficial to some learners, but is it beneficial to preservice teachers? How effective are teaching simulations (classroom teaching video vignettes) for teacher education? How do preservice teachers learn from this type of curriculum presentation? How does it effect later teaching? While there are studies about initial technology use as a teacher, we don't know how teachers use technology over time (longitudinally). As they become more expert at day-to-day teaching

and management of the classroom and more expert with the technology, do they more effectively teach with technology? If we can answer questions like these (and a multitude of others), technology will be used to the most effective extent possible, as it is implemented and as ongoing research is conducted in teacher education settings.

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Technology and Teacher Education: A Research and Development Agenda

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A great deal of the academic effort invested in research on educational computing, including the use of technology in teacher education, is based on a research model developed and nurtured in the social sciences—especially psychology. In this paper, I will argue that the requirements and the purposes of social science laboratory research are not always congruent with the requirements and purposes of research and scholarship in the area of technology and teacher education. I propose an alternative model for research and development in the area of technology and teacher education that is, at least, a desirable alternative and, at most, the preferred option at this stage in the development of a field like technology and teacher education. The model I propose, instructional development (ID), has emerged from the field of instructional technology.

Research to Support Theory

Much of the educational computing research currently available is based on a social science research model that views research as a means of testing and supporting theories. That model was the centerpiece of American psychology for much of this century. From this perspective hundreds of thousands of studies have been conducted to support one grand theory over another. In spite of the limited success of the grand research-to-support-theory (RTST) model in psychology over the past 90 years, it is still commonly used in educational computing and instruc-

tional technology research. In the fledgling field of technology and teacher education, it may be viewed by many as the default model for "good" research. A typical study compares a type of courseware such as drill and practice to "traditional methods." If the results favor the courseware, authors conclude that drill-and-practice software in general is more effective as an instructional strategy than traditional methods. The particular drill-and-practice program used is considered a representative of all drill-and-practice programs. In an emerging applied field like technology and teacher education, however, there are several reasons to reject the RTST model and opt for a more applied, more product-oriented model.

Research-to-Support-Theory Is Too Limiting

In the broader field of instructional technology, thousands of traditional research studies have now been conducted. They generally compare some use of instructional technology to traditional instruction and conclude that the instructional technology studied is better, equivalent to, or worse than traditional instruction, however that is defined. Over the past 30 years a number of authors have also published reviews of educational computing research (Kulik, Bangert, & Williams, 1983; Kulik, Kulik, & Bangert-Drowns, 1984). In fact, we now have enough research reviews to support an extended and detailed evaluation of such reviews (Roblyer, Castine, & King, 1988).

The conclusions drawn from recent general reviews such as Roblyer, et al. (1988) are, for the most part, positive toward computer-based instruction, and there is no doubt that as traditional research studies in the area of technology and teacher education accumulate, similar positive reviews will be written on those studies. However, from a broader perspective, there are reasons to question the validity and generalizability of both individual research studies and research reviews. Those reasons apply regardless of whether the conclusions are positive or negative toward the instructional innovation studied.

A number of authors are highly critical of this type of research. Hagler and Knowlton (1988) use phrases like "faultily conceived and fruitless research" in referring to much of the current crop of studies that compare computer-based instruction (CBI) to instruction delivered by other methods. Hagler and Knowlton (1988) and Clark (1985) argue that most of the comparisons between traditional instruction and computer-based instruction are fatally flawed because they fail to control potentially powerful confounding variables. It is certainly true that in many of the studies comparing CBI to traditional instruction (TI) the CBI groups received a different type of instruction, spent a different amount of time studying, or were taught by different teachers. Any of these

variables—different content or instructional strategies, more or less study time, or different instructor—could account for the superiority of the CBI group. In an RTST model, this is certainly a fatal flaw because the goal is to support a general theory (e.g., that CBI is superior to TI), and all alternative explanations of the results (e.g., students had more time to study) must be eliminated. Most of the criticisms of current CBI research are based on the assumption that the RTST model is the most appropriate one to use and therefore the quality of an individual research study is determined by the study's contribution to the debate over whether CBI is inherently superior to TI. Applied to the field of technology and teacher education, the goal of research in the RTST tradition would be to evaluate CBI in teacher education versus TI strategies used in teacher education.

From the perspective of the RTST model, the solution to low quality research is simple: We need fewer studies with confounding variables and more studies where everything except the medium is held constant. As Hagler and Knowlton (1987) put it,

Those interested in teaching and learning cannot confuse the message with the medium. Any attempt to compare media, such as comparing traditional instructional methods with CAI, would have as a dependent variable some measure of learning. All message variables would have to remain constant, with medium being the only variable allowed to change. (p. 86)

Wesley, Rockover, and Hicks (1985), for example, taught education students basic research skills. One group learned through a printed text. Another group read the same material on a computer screen. As you might expect, there was no difference in the performance of the two groups on a posttest. Clark (1985) would not be surprised by such results because he argues that when all potentially confounding variables such as instructional strategy and content are controlled, there is no reason to expect that CBI will be any more effective than instruction delivered through any other medium. Using Clark's perspective as a beginning point, it is clear that when meta-analytic studies by Kulik et al. (1985) draw general conclusions about the effectiveness of CBI, they are adopting the RTST model. Clark points out, however, that the studies that serve as data for meta-analyses do not meet the criteria of the RTST model. CBI versus traditional instruction comparisons are confounded with other variables that mean the reported superiority of CBI could be due to other factors (Clark & Stuart, 1985). Because so much of the research comparing CBI to other types of instruction suffers from confounding, Clark (1984) has suggested this type of research be halted.

The insistence on keeping all instructional variables other than the medium of instruction constant across experimental and control groups

is probably necessary if we adopt the RTST research model, and our interest lies in answering the theoretical question, "Is CBI better than TI?" Much of the literature on the validity of comparisons between technology-infused instruction and other methods revolves around this issue. Unfortunately, the resulting research may not be very interesting or innovative. For example, one study of text density (Morrison, Ross, & O'Dell, 1988) taught college students a lesson on statistics. The results of one part of the study indicated a shortened but well formatted version of the study text was more effective than a longer version. A second focus of the study is more difficult to interpret. Some students read the material in printed form while others viewed the information on a computer screen. The so-called computerized lessons did not use the computer's ability to provide feedback or select information tailored to the students' pattern of errors. Students who read the printed material scored much higher on two of four posttests and took significantly less time than those who received information via the computer screen. The results show that simply converting printed lessons to "computer" lessons may be detrimental to learning. Morrison, et al. used Apple II computers in their study, and few would argue with the proposition that reading text from an Apple II screen is not likely to be more effective than reading the same text on paper. If CBI does have an advantage over printed text, the superiority does not lie in the quality of an Apple II text display.

The RTST model directs our attention to research that keeps everything constant except the medium, such as text on a video screen versus text on sheets of paper. However, much of the appeal of CBI lies in the computer's ability to deliver instruction with features that would be impossible, or very expensive and difficult, to deliver through any other medium. The RTST model directs our attention away from such features because including them produces a confounding in the research. It is those "confounding" variables that may be the essence of CBI's advantages. It would be interesting to know, for example, if the results of the Morrison, et al. study would be the same if the short and long versions of the text material were converted to hypertext so that students reading it from the screen of a high resolution monitor could click hot buttons to get additional information and examples of terms and concepts on demand. Such a study would not, however, be a "good" study from the RTST perspective because the hypermedia features of the CBI program could not be replicated in the printed material.

Some of the most interesting CBI, such as instructional simulations and hypermedia, use computers precisely because it is difficult to provide similar experiences without the aid of the computer. Studies that compare innovative uses of technology in instruction to TI rarely, if ever, use the same instructional strategies and instructional material

in the experimental and control groups. The RTST model calls on us to pay a high price to meet the standards required to answer the theoretical question: Is CBI better than TI? There is, however, good reason to believe the theoretical question cannot, and should not, be answered by such research.

The Logic Underlying RTST Is Not Valid

The RTST model is based on a number of assumptions. If any one of those assumptions is not valid, the whole RTST enterprise is also not valid. The problem of confounding in most available studies has already been discussed. There is, however, another related assumption that is as important. In his reply to Clark's (1985) critical analysis of comparative research on CBI, Cunningham (1986) points out that many comparative research studies of CBI and TI are based on a logical positivism that allows researchers to develop constructs such as *computer-based instruction* and *traditional instruction*. Within the RTST model, these constructs represent the basic kernels of CBI and TI. Instances of CBI and TI will vary considerably from one study to another, but the kernels are always present. When we conduct research to determine whether CBI is superior to TI, we are really talking about the two logical constructs, CBI and TI. They represent the essence of these two types of instructional strategies.

If this logic is accepted, then the path to Truth about CBI and TI is through reviews of research. In any individual comparative study the outcome is determined by two types of independent variables. There are variables that represent the kernels of the CBI and TI constructs. There are also unique aspects of the specific CBI and TI used in that particular study. If any one study reports that CBI is superior to or less effective than TI, there is no way to determine whether the results are due primarily to "kernel" elements or unique aspects of the particular CBI and TI used. The conclusions of reviews, particularly meta-analytic reviews, move us closer to the Truth about CBI and TI. By summarizing the results of many research studies we can reduce or eliminate the effect of those unique factors and distill the Truth about the CBI and TI constructs. Clark (1985) generally accepts this approach, but he believes it has failed thus far because the experimental and control groups in most studies differ not only in terms of basic and unique aspects of CBI and TI but in other ways as well such as time spent on task. This type of confounding is common in current CBI research and that is one reason why we cannot draw valid conclusions from it. Using research with significant confounding can even hide important issues that influence the effectiveness of CBI. McGowan and Clark (1985), for example, argue that many software designers are guided by a behavioral model of

learners and thus produce software that aids low-ability students and hinders high-ability students while the use of cognitive models would yield software that is more effective for high-ability students.

Within the RTST model, the logical thing to do at this point is improve the quality of research. Cunningham (1986), to the contrary, has problems with the approach itself. For him the answer is not to eliminate confounding and do better research within the RTST model. That approach, which would lead us to the identification of the "Good Guys" and the "Bad Guys," is inherently flawed. The logical constructs of CBI and TI do not work. They are too broad, too diverse, to be useful.

If CBI and TI are not useful constructs, is the search for an answer to the question of whether CBI or TI is superior also fruitless? For some the answer is both yes and no. Some propose that we continue our search for the good guy and the bad guy. However, as we search we must keep in mind that the effectiveness of CBI or TI is determined, at least in part, by factors such as the type of content being taught and the personalities of the students. This modified RTST model, sometimes referred to as the Aptitude-Treatment Interaction model, still relies heavily on the constructs of CBI and TI, and it assumes that we can discover truths about these two constructs. However, the truths we discover will not necessarily be broad, sweeping truths that apply at all levels of instruction, for all types of instructional objectives, and for all types of students. Simulations, for example, may be effective for preparing teacher education students to manage a classroom but they may not be the best instructional medium for delivering instruction on theories of child development. Cunningham argues that the basic problem lies in the assumption that we can isolate a "pure CBI construct." If that construct does not exist, then all the efforts within the RTST model to identify the Good Guy and the Bad Guy will be fruitless.

Is there an enduring kernel of similarity that is shared between a simple drill-and-practice arithmetic program and a complex simulation of international diplomacy? Can we take the conclusions of meta-analyses based primarily on studies of text-only, drill-and-practice and tutorial software running on mainframe computers and apply those conclusions to the use of instructional simulations like *Oregon Trail* or *Balance of Power*? No we cannot. A simulation in which students play the role of a teacher in a classroom has more in common with a stirring lecture that recounts critical incidents in the classroom than it does with a drill-and-practice program that requires you to match the names of theorists with their approach to classroom management. There is no valid CBI construct that represents an important kernel of commonality across all forms of CBI, and the energy invested in attempting to show that CBI is superior, either in a general or in some specific way, is likely to be wasted. Narrowing the focus to a particular type of CBI does not

solve the problem. For example, some hypermedia packages are more like rote memorization drills than they are other hypermedia programs.

What is Cunningham's solution? It is relatively simple. He believes

there is no such thing as "the truth of the matter" that CBI is better than TI or vice versa. The relative effectiveness of those two methods is dependent upon an enormous number of other factors, so great a number that they could never be accommodated within any single study or even within any group of studies. (p. 5)

Cunningham, along with others such as Scarr (1985), suggests we think of research not as a process of discovering knowledge but as a process of constructing knowledge. Knowledge is not, however, Truth that once discovered, remains stable and dependable forever. Rather, "Knowledge is a construction of the human mind and 'facts' that are invented within the context of one theoretical perspective become different 'facts' within another theoretical perspective" (p. 5). Within Cunningham's framework the goal of research on instructional alternatives becomes a search for truth that is very local and transitory.

Our inquiry will never produce laws that generalize across all possible circumstances. We will *never* be able to say that CBI is better or worse than TI without embedding that statement within particular interpretive contexts (social, historical, cultural, etc.).

When the interpretive context changes, the usefulness or effectiveness of the application will likely also change.

Let's invest our energies in exploring the potential utility of as many instructional techniques as we can think of rather than pitting them against one another. Is CBI better than TI? Since the question can not be answered, why don't we simply try to do as good a job of each as we can. The result might even be good instruction. (p. 6-7)

Cunningham's solution has much in common with the reflective practice model of Donald Schön that is popular today as a framework for developing professional teachers. Those who accept logical positivism as the best philosophical and epistemological framework for research are likely to find Cunningham's solution uncomfortable, even illogical and disturbing. Those who adopt one of the competing epistemologies such as constructivism or phenomenology (Berkenkotter, 1989) may find the solution much more suited to the way they think about professional practice, the preparation of teachers, and the development of knowledge. In their defense of the traditional experimental method as the only way of avoiding, among other things, "faddish discard of old wisdom in favor of inferior novelties" (p. 2), Campbell

and Stanley (1966) note that "defections from experimentation to essay writing" often occur when researchers who are well trained in the traditional research model convert from "a Thorndikian behaviorism to Gestalt psychology or psychoanalysis" (p.2). The RTST model is a model of research that flows logically from some forms of philosophy, some approaches to the origin of knowledge, and some theories of human behavior. Alternative models of research flow logically from other philosophies, epistemologies, and theories of human behavior.

If we adopt Cunningham's perspective, it does not mean that research on technology and teacher education in the RTST model is useless. It simply means the results of those studies must be interpreted in a much more circumscribed, localized way. From this perspective, studies in the RTST tradition are usable, but as noted earlier, continued use of the model places some unacceptable limitations on what we study. Those limitations stifle work on the instructional innovations we need most in the area of technology and teacher education. The RTST model is not likely to produce the highest yield of useful information. The instructional development model discussed in the next section seems much more suited to the type of research Cunningham suggests.

The Instructional Development Research Model

Even if we abandon the general construct of CBI and develop narrower logical constructs, such as *technology in teacher education*, there is still little likelihood that we will discover enduring Truth through RTST. Because there is no one monolithic, unitary entity called technology in teacher education (or lecturing in teacher education, cooperative learning in teacher education, or microteaching in teacher education), it is not possible to draw general conclusions from Good Way versus Bad Way studies. The time and effort invested in such research would be better spent on other questions. For example, in their review of simulations in science education Wells and Berger (1985/86) were concerned because some research studies reported science education simulations were effective when compared to traditional instruction (Boblik, 1972) while others did not (Hollen, Bunderson, & Dunham, 1971). They comment that "It is not clear why the research provides conflicting results on the effectiveness of computer simulation" (p. 35), and they speculate on the reasons why there are conflicting results (peaking out effects, weak measures of the dependent variables, measurement of the wrong dependent variables). All these questions reflect the focus of the RTST model—to eliminate confounding variables and get at the "essence" of the relationship between CBI and TI. There is another alternative explanation. Some simulations are effective; others are not. Some lectures are effective; others are not. Some demonstrations, videos,

classroom visits, student teaching experiences, and microteaching exercises are effective; others are not. There is no guarantee that every instructional effort with the name hypermedia attached to it is effective at accomplishing a particular set of instructional objectives. We should not expect every study to report positive results and we should not interpret positive or negative results on one instructional innovation as an indication that all instructional innovations of the same type would yield the same positive or negative results. Although practitioners generally understand that a study reporting positive results with a particular method such as simulations does not necessarily mean all, or even most, simulations will yield the same type of results, the research reviews generally do not. They often come to conclusions that lump a wide range of instructional strategies, types of computer software, and integration schemes into the same conceptual stew in order to draw broad conclusions. For example, in their critique of reviews Robyler, et al. (1988) used that approach to conclude that "computer applications have a higher probability of meeting with greater success at college and adult levels than at elementary and secondary levels" (p. 73). Drawing such conclusions from research on a broad range of technology-supported instructional packages is routine in the reviews, however.

Another reason to discard the RTST model is the dampening effect it has on research. Because it is relatively rigid in the type of study that is acceptable, it discourages developers from conducting systematic research on the effectiveness of their instructional packages because they know they cannot meet the "standards" of the RTST model. Much of the work on innovative uses of technology in teacher education does not report any systematic data on the innovation. A good example of this type of article is Ferguson and Evans' (1989) description of an effort to improve the writing skills of undergraduate teacher education students by teaching them to use word processors. The article contains a great deal of useful information that would be helpful to a teacher educator who is considering adopting a similar approach. The instructional effectiveness of the introduction of word processing use at Deakin University in Australia was not, however, formally evaluated. Another paper (Brown & Gliessman, 1988) deals with the use of computer-controlled video in teacher education. As with the Ferguson and Evans paper, this article describes the implementation of an innovative technology in teacher education, but there is no formal research. From the perspective of RTST model these two articles should never have been published. They do not even represent bad research with many confounding variables; they report no research at all! On the other hand, both articles offer readers a rich description of the process of implementing an innovation in teacher education, and both discuss potential problems and describe an instructional innovation that other instructors

would find very useful. Articles of this type are often severely criticized, but they are also read thoroughly by practitioners who find them very useful. Is there an alternative to the RTST model that acknowledges the value of research and development work that does not require control-experimental group comparisons? Is there a model that could be used by practitioner/developers such as Brown and Gliessman?

One attractive option to the RTST model is the Instructional Development (ID) model. In the ID model, the primary goal is not to prove that one general type of instruction is better than another; the goal is to develop an instructional package. The package might be hypermedia instruction on the induction year, a computer simulation on planning a junior high mathematics class, or an interactive video package on wait time for classroom questioning. In any case, the goal is to develop high quality instruction. In accomplishing that goal, the developer is likely to violate many of the basic guidelines of the RTST model. For example, the instructional package need not be limited to one particular instructional approach. An effective package that includes lectures, demonstrations, and interactive video does not represent a reprehensible confounding of independent variables from the ID perspective. If it is an effective, efficient way of delivering instruction, it represents success rather than failure. At this stage in the development of technology and teacher education, that is an important and achievable goal. Technology and teacher education is an applied field that can draw on theoretical research from many fields. It cannot, however, take instructional packages from those fields. It must grow its own. If we are ever to break out of the small "techno-ghetto" we occupy in teacher education and bring technology into the mainstream, we need useful, usable instructional products. We need more teacher education software packages, more instructional modules on the curricular integration of technology, and more carefully developed instructional methods that can be shared with other colleagues. While the primary products of the RTST model are articles, the primary products of ID research are instructional packages.

Elements of The Instructional Development Research Model

There are many variations of the Instructional Development (ID) research model such as the popular variation described by Dick and Carey (1985). A classic expression, though heavily behavioral, is the 4-D Instructional Development model of Thiagarajan, Semmel, and Semmel (1974). Like all the other ID research models, the focus of this model is on the development of quality instructional material to accomplish a clearly specified set of objectives for a clearly specified group of students. The 4-D model has four stages: (a) Define, (b) Design, (c) Develop, and (d) Disseminate. Space is not available to discuss the ID

model in full, but a brief description will illustrate the thrust of the model. The four steps in the model all contribute to the ultimate goal of developing and disseminating effective, efficient instructional packages.

The Definition Stage

This stage covers the preliminary analytical steps required to develop any type of instructional material. The purpose of this stage is the identification and definition of instructional requirements. There are five steps in this stage. They deal with the determination of need (perhaps a good package has already been developed), learner analysis, task and concept analysis, and specification of instructional objectives.

This description of ID, like many, presents the steps in linear fashion. However, it is rarely linear in practice. Few developers finish each stage and step in sequence and then move on to the next. In many cases, for example, a comprehensive and clear statement of instructional objectives may not be completed until the package has been developed and at least partially evaluated.

The Design Stage

The overall objective of this stage is the design of *prototype* instructional material. Developing a prototype involves selecting the media (e.g., computer display, videotape) and format (such as drill and practice, tutorials, simulation, hypermedia) and initial design.

The Development Stage

Once the instructional package has been designed, the third stage begins. In this stage the initial prototype is subjected to two types of formative evaluation: expert appraisal (such as content specialists, experienced instructors, instructional design specialists) and tryouts or field tests. In their discussion of formative evaluation, Dick and Carey (1985) suggest that much valuable information can be obtained by simply asking the students who participate in the field test for comments and suggestions. For example, Wood, Combs, and Swan (1985) used student questionnaire data as the dependent variable in their evaluation of a simulation designed to teach preservice and inservice teachers how to deliver instruction in a special education class. Schieman and Winn (1983) used a similar evaluation format when they developed two simulations to help teachers learn classroom management skills. The goal of both expert appraisal and developmental testing is to gather information that can be used to revise and improve a specific simulation. The feedback/revise process is often repeated several times.

The expert appraisal and developmental testing steps in the ID model have no formal equivalents in the RTST model. All the focus in the RTST model is on the single research study that either supports or does not support the theory. Expert appraisal and developmental testing are both well established components of the software development process, however. Complex applications software such as word processors, spreadsheets, and databases are subjected to extended expert appraisal and developmental testing before the commercial versions are offered for sale. Beta testing, which involves use of the software by selected consumers, often identifies bugs and problems that must be corrected before the software is offered for sale. This process is a crucial aspect of developing a quality product.

Dissemination Stage

The final stage in the ID model includes a summative evaluation of the final version of the instructional package, final packaging, diffusion, and adoption. Summative evaluation may involve a formal study that uses experimental or quasi-experimental designs similar to those used in RTST research. As with formative evaluation, there are two types of summative evaluation. One method of summative evaluation relies on the opinion of users. Experts can be asked to evaluate and critique the final version of the package. This step is similar to software reviews published in outlets such as *InfoWorld*, *MacWorld*, or *PC Magazine*. Software reviews are generally written by experts who put the program through its paces and then critically evaluate it in terms of the purpose for which it was designed.

In the ID model, the summative evaluation provides potential users (including the developer) with information on the effectiveness of the instructional package. The software review format is one approach to that goal, but most ID projects will also use more traditional evaluation strategies. For example, Willis' (1989) summative evaluation of a teacher education simulation used a traditional experimental/control group design with random assignment to groups. This type of summative evaluation, with features such as random assignment, is often impossible to use in educational settings. Fortunately there are a number of research designs that can be used in situations that provide less than ideal research opportunities. Thiagarajan, et al. (1974) describe several summative research designs including the use of intact classes, a within-class posttest-only design, a time series design, and single subject designs. Campbell and Stanley (1963) provide a concise description and critique of many potential designs. Where the lack of random assignment to groups is a threat to validity, Huitema (1980) is one of the most thorough and usable texts on design and analysis alternatives when students cannot be randomly assigned to groups.

When an experimental or quasi-experimental design is used in the RTST model, the goal is to generate data that contributes to our understanding of a particular theory or set of theories. The topic may be basic (e.g., children construct schemas through assimilation and accommodation) or applied (e.g., teacher education students learn effective questioning techniques more effectively through computer-based simulations than traditional instruction). The same research design, or the same study for that matter, may have a very different purpose in the ID model. There the purpose of the research is to evaluate the effectiveness of a specific instructional package. If that package is a particular type, such as hypermedia, a successful summative evaluation reflects on that package alone. It does not support a RTST-style conclusion that hypermedia are in general superior to other methods. Some proponents of technology in teacher education may question this position. Why not generalize from a summative evaluation of one instructional package to all packages that use similar techniques? There are many reasons. Most effective instructional packages use many different instructional strategies in combination. It is difficult to identify which components contribute to effectiveness and which do not. In addition, the package is used at a particular point in instruction, after some experiences and before others. Those variables, which are rarely explained fully in research reports, may influence effectiveness. Finally, packages that deal with complex skills or concepts are generally not so robust that they are effective regardless of the instructor. A major factor in most success stories is the instructor, even when technology is a major part of the instructional delivery system. Given the number of factors that can influence the success, or failure, of instructional packages, it is much more sensible to limit severely any generalization based on one study. That does not mean, however, that every study is an island, with no connection to the rest of the literature. If many developers report success using a particular approach, such as hypermedia, microteaching, or collaborative conferencing, to achieve instructional objectives similar to those of interest to you, it makes sense to explore those alternatives in your own development work. In addition, professional practice papers written by experienced teacher educators with experience in developing and using similar packages would also be very helpful to new developers and new users.

The final stages of the ID model involve packaging the product for distribution, locating a channel for distributing the product, and assisting those who adopt the product and begin using it. These steps can be the most difficult of all and few packages in teacher education ever reach the point where they are widely available to the profession. Other instructional media such as textbooks are well supported by commercial publishers, but the small size of the potential market for innovative packages is not likely to attract commercial publishers.

What We Need Now

The ID model has a different purpose and therefore has different methods and strategies. It is not, however, an atheoretical or anti-theoretical model. On the contrary, many researchers who use an ID model rely heavily on both theory and basic research. The emphasis, however, is on the use of theory and basic research rather than the study of theory. ID researchers are more often consumers of theory and basic research than contributors.

The ID model is a desirable model for technology and teacher education at the moment. We need validated instructional packages in the field. Faculty in fields such as English, chemistry, physics, mathematics, psychology, history, and sociology can choose from a growing collection of instructional software developed specifically for that discipline. That is in stark contrast to the field of teacher education. There are few technology-intensive instructional packages for teacher education in widespread distribution today. In comparison to colleagues in many other fields, teacher educators face a rather bare cupboard when they look for technology designed specifically for teacher education. Adoption of the ID model of research is one way to contribute to the resolution of this problem.

However, the ID model is not something to be used simply because it is there. It provides a framework within which to think about the process of designing any type of instructional material. Some developers are well aware of the ID model and make informed decisions about the steps they will use and those they will eliminate when they create a new instructional package. Even a cursory review of the general instructional software literature indicates, however, that many developers do not use an ID model because they have little, if any, awareness of it. I suggest that the quality of instructional packages relevant to technology and teacher education would be higher if developers made informed choices about the steps in the ID model. I suggest further that a shift in research focus among faculty interested in technology and teacher education away from the RTST model and to the ID model is very much needed.

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A Systems Integration Approach to Researching the Role of Technology in Professional Development

Douglas M. Brooks

The dynamic culture of the information age has continued to produce an expanding number of intelligent tools, learning systems, and opportunities for professional development. At the same time, the maturing field of cognitive science has revealed that individual learners perceive and process new and difficult information using "learner systems"; internal cognitive processes and knowledge representations such as learning styles (West, Farmer, & Wolff, 1991). Taken together, these developments have delivered educational researchers to the edge of a new "systems integration" frontier.

Researching Systems Integration

The necessary conditions for programmatic research on systems integration would be the identification of the certification program statement(s) of professional development and the determination of established or promising technologies that might improve the existing or proposed program system. In short: (a) What program statement is being researched? and (b) What technology is being researched? Once these two parameters had been determined, hypotheses on experimental integrated systems could be tested for their effect, efficiency, and user impact on professional development. The typical program/administrative structures such as prestudent teaching, student teaching, inservice, and so forth would become transparent in a fully developed systems integration program of research on professional development.

Within a systems integration approach all technological components of the system would serve the end user. The goals of systems service would be defined by statements of professional development. These statements would also serve as the baseline survey questions in the systems analysis stage of a systems development life cycle (SDLC) approach to the development of a systems integration model for professional development. Technologies would be evaluated within the SDLC paradigm for their effectiveness, efficiency, and end user impact.

The SDLC offers an excellent model for integrated systems analysis, systems design, systems implementation, and systems support. This nine-stage model is guided by six basic principles, the first and most important of which is central to the systems integration model: the site-based needs of the customer. Current successes, at the macrosystems level, include distanced learning via satellite in distanced geographic areas such as Alaska, Oklahoma, Texas, and Australia. Projected successes at the microsystems level feature individual learner workstations connected to a high speed data network that would let everyone from university scientists to grade school students use supercomputers. Distanced learning is exemplified at the Institute for Telecommunications at Oklahoma State University. The vision of a proposed high speed communications network has been proposed by CEOs of US computer makers who belong to the Computer Systems Policy Project. The group includes Apple, IBM, DEC, Cray Research, and Hewlett-Packard Company.

"Tools Stage" Research

The basic assumption of the "tools stage" of inquiry is that the use of discrete systems such as the video recorder, computer, television, and related technologies in a program of study will enhance learner professional development. In "tools stage" inquiry, if computer software on diagnosing learning disabled learners is introduced in educational psychology, then the assumption is that the preservice learner will be a better teacher. In our review of technology in teacher education (Brooks & Kopp, 1990), we attempted to capture the status of "tools stage" research on technology and teacher preparation. We avoided reviewing and reporting studies "by technologies." Instead we identified a series of 16 statements of professional development and used these statements as primary organizers for the report. The 16 statements of professional development were used as program organizers for individual technology research. The list is adapted from a list that originated in the late 1960s at the University of Houston, was modified at the University of Texas at Arlington and was again modified at Miami University in Oxford, Ohio in the late 1980s. At each of the three locations, the

statements of professional development guided the selection of individual course content, technological enhancements, field and clinical experiences, and senior internship supervision and performance evaluation. In theory, the statements also served to guide departments outside teacher education in the selection of content and course development for professional certification.

For example, a published study might report the application of videotape technologies toward improving student teacher instructional behavior. We would then ask the question "What program statement was the study attempting to address?" We then categorized the study within a statement of professional development such as "Demonstrates a Repertoire of Appropriate Teacher Skills and Behaviors." Our intent was to be able to examine the presence and impact of individual "tool" technologies within an individual program statements. The technology factored by program statement of professional development approach to the review permitted the following conclusions:

- Gaping holes existed in the application of many technologies within major program themes.
- Technology had the most presence in media courses and "methods" level microteaching.
- There was a complete absence of audiotape technology to accomplish any of the program statements.
- For classroom teachers, the most significant exposure to emerging technologies was occurring at the inservice level.
- It appeared that the culture of undergraduate teacher preparation lacked the ability to be responsive or evolve.
- The emerging technology of computer networking held great promise as an example of a technological system that could be integrated into professional development programs and be end-user friendly.

"Tool Stage" Summaries Within Statements of Professional Development

The following statements of professional development have been expressed in systems integration language. The end user would be the undergraduate learner. The statements would be the continuously improving professional culture of the professional educator regardless of their location in a program of study or professional contract assignment.

The end user would do the following:

(1) Identify the Learner's Emotional, Social, Physical, and Intellectual Characteristics for the Purpose of Instruction

Sudzina (1991) reports organizing students in an undergraduate educational psychology class into cooperative learning teams. The goal of the five-student teams was to develop audiotapes that would serve as learning tools to support the textbook and lectures and improve performance on examinations. She reports high student engagement, improved student questions, and improved use of professional vocabulary on tests. Serendipitous findings included that most of students already owned the cassette recorders for production and Walkmans for listening. She also reported that students in the nonexperimental sections of study sought to "bootleg" the audiotapes of the experimental group making the tapes.

(2) Identify and Provide the Rationale, Goals, and Objectives in Curricular Planning

Universities are establishing computer networks that link senior interns with internal and external mentors as well as additional systems resources. The presence of a network permits the development and review of instructional activity plans from distanced workstations. The potential seems limitless for the study of professional development using data transmitted and stored on networks. Maturation in thought and conflict resolution could be charted within the permanent records these systems could hold.

(3) Design Instructional Methodology in Media and Technology Appropriate to Instructional Goals and Objectives

As audiotape and videotape technologies become increasingly saturated in the culture, their application to instructional design becomes more simplified. Research, within this statement, may have less to do with actually using the tools and more to do with what planning models will move "technology as an instructional tool" to the level of automaticity.

(4) Select and Adapt Curriculum Resources Including Media and Technology Appropriate to Identified Instructional Goals and Objectives

Research might target how teachers and professors in teacher education programs effectively build and integrate audiotapes, videotapes, cable TV, satellite supported communications, computer labs,

computer networks, and distanced learning into learning experiences. It appears that undergraduate programs offer little assistance in how to manage or creatively apply many of these technologies.

(5) Develop Curricular Materials that Reflect a Culturally Diverse Society

The camcorder, video encyclopedias, the recent release of Sony's "Dataman" and low cost audiotapes are redefining access to the realities of cultural diversity. Teacher education programs could be presenting models for developing teacher-built diversity experiences using audiotapes, videotapes, and computer simulations.

(6) Develop Curricular Materials and Instructional Methodologies that Enhance the Learning of Culturally Different Learners

Private-sector-produced science education videodiscs are often multilingual. With a press of a mouse, the video-based tour changes languages. The impact of experience with these tools during the senior internship and before needs to be investigated. As the multicultural population in public schools continues to increase, new teacher readiness to implement multi-language curriculum must mature.

(7) Develop Curricular Materials and Instructional Methodologies that Enhance the Learning of Exceptional Learners

Videotaped case study comparisons of "before and after" training for learners with physical and emotional handicaps could be shown to undergraduates. The tapes could include examples of what outcomes can reasonably be expected from specific interventions. Interviews of how students, at different grade levels, respond to student teachers are probably rare, if nonexistent.

(8) Incorporate Instruction in Reading, Critical Thinking, Problem Solving, and Study Skills to Enhance Learning

Computer simulations could be constructed to present undergraduates with typical grade-level-specific writing, thinking, and study problems. These programs could reside in computer labs or be placed on individual diskettes, distributed in class or sold at bookstores as "workdiscs." Any technologically supported application that helps students to prepare for the reality shock of the senior internship should reduce the seriousness of the shock and the negative effects and feelings of incompetence.

(9) Organize a Positive Classroom Environment to Enhance Learning

Camcorders can be used while observing senior interns. Filming space organization, desk arrangements, room decorations, curriculum materials, closets, bookcases, and technology present in the room can give undergraduates a holistic perception of the classroom. Videotape can later be shown to preservice classes that meet "on campus" to establish a common frame of reference for discussions. The impact of this treatment effect could be investigated.

(10) Apply Effective Patterns of Communication in the School and Community

Elementary classroom teachers could be videotaped welcoming parents to the classroom on the first day of school. The film might demonstrate to undergraduates in a classroom management class that they need to know how to effectively greet and reassure parents, as well as students, at the beginning of the school year. Undergraduates may have forgotten about coming to school with their parents and probably do not have children.

(11) Implement Individual and Group Management Skills

The impact of videotape reviews of senior intern performance can not be overstated. Videotaping an intern, allowing the intern to review the tape alone, and then reviewing the tape with them appears to develop the intern's reflectivity and encourage a willingness to discuss improvement with mentors. Grade-level-specific video examples provide opportunities to see the subtle but important differences in style required for effective classroom management.

(12) Implement Instructional Methodologies to Complement Goals and Objectives

University professional educators should start producing their own videos taken from area schools and professional growth experiences. For example, at the conclusion of each semester, a meeting with all senior interns could be videotaped. In that meeting the interns could be encouraged to discuss problems they confronted and ways they resolved them. The videotape could then be distributed at the first meeting of new interns. Second generation senior interns might then feel less isolated and guilty about coping with their novice status.

(13) Demonstrate a Repertoire of Appropriate Teacher Skills and Behaviors

Videotape comparisons of expert and novice teachers managing critical classroom contexts such as opening the class, transitions between activities, and student questioning could provide classic example/nonexample learning opportunities. These films could be made with the combination of internal experts and senior intern performances.

(14) Design and Implement, for Diagnostic and Prescriptive Purposes, Student Evaluation Instruments and Strategies

Videotape demonstrations of proper and improper classroom test supervision could be developed or role played. Computer-stored test item banks could assist in test preparation. Examples of good and bad test designs could be created, placed in simulations and discussed. Computer networks would permit long distance editing between experienced educators and novices.

(15) Demonstrate the Ability to Synthesize and Evaluate the Structure, History, Philosophy, Governance, and the Current Issues in Education

Videotapes or audiotapes circulated among senior interns could become the common frame of reference for seminars. The tapes could come from newscasts, broadcast, cable station productions, or professional group audio series. The seminar group would not have to sit and watch the tapes together but rather could watch them at convenient times and use the seminar for full discussion.

(16) Demonstrate a Willingness and Ability to Evaluate and Improve Instructional and Professional Effectiveness

Senior seminars attached to senior internships are notoriously difficult to schedule and may very well set the stage for negative attitudes toward organized staff developments. In a recent experiment, Brooks (1991) developed a series of eight audiotapes for twelve senior interns. The series topics included: an orientation to the statements of professional development, routine intern concerns and possible solutions, an orientation by an experienced and successful mentor on strategies for success in the internship, classroom management, learning styles and midterm and final conferences. Also included were

audiotapes featuring articles from ASCD's Educational Leadership and selected tapes from a professional management series.

The impact of these tapes has been encouraging. Internal mentors have asked to listen to the audiotapes. All interns and mentors drive to work and have cassette recorders in their cars. The interns reported not feeling abandoned and appreciated the customized design of the series.

Conclusion

Increasing competition, advanced miniaturization, niche marketing, and user friendliness has put many of the "intelligent tools" and learning systems of the information age in reach of public school budgets. However, the acquisition process is rarely systematic with a long range view toward integration. Information technologies find their way into the learning environments a problem at a time, a directive at a time, or an opportunity at a time. Yet all problems, opportunities, and directives are evaluated in terms of their bottom line impact on performance, information management, economy, control, security, efficiency, and customer service. Hardware usually becomes outdated as the tool loses power to occupationally socialize.

The systems integration challenge in the 90s and beyond is to integrate new learning systems without losing the investment of older systems. It is no longer enough to buy or build systems that fulfill requirements. It is no longer enough to purchase or build systems that are easy to maintain. We must integrate or interface those systems to the myriad of existing and potential systems that will improve learning. More important than designing and building these systems, educators should design research programs for continuous improvement. These rarely exist in professional education. They always exist in successful business.

Today's classroom may have an overhead projector, a VCR and color monitor, a computer workstation, cable access, reading systems, mathematics systems, and computerized dissection software but parents still do not know what curriculum is in the coming week's activities or how to assist at home or efficiently make contact with the teacher. The classroom sits as a collection of individualized but hardly integrated learning systems, and almost always an island remote from not only the home, but also other classrooms in the same building!

Thompson Consumer Electronics, maker of RCA and GE televisions, recently announced that it would help launch a satellite-to-home TV broadcasting system through a venture with the Hughes Electronics division of General Motors. The system called DirectTV is scheduled to go into operation in 1994. It will provide more than 100 channels to 18-inch satellite dishes installed outside homes. The dish and related

equipment will cost about \$700 and be sold in electronic stores. This new system will be based on the digital technology used in computers to provide distortion free pictures.

In an emerging culture of supercomputers and DirectTV, the "New American School" must be shaped with a commitment to systems integration if it is to serve the full human resource development of the leaders in "Emerging American Learning Community."

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Current Research in Technology and Teacher Education: Three Phases of Our Mission

D. LaMont Johnson and Steven D. Harlow

There are two major reasons for teacher education programs to embrace technology. The first is to prepare teachers to familiarize their students with technology and thereby better prepare them to live and work in a world permeated with technology. The second, and in our opinion, much more important reason is to experiment with using technology to change education. Such experimentation would then be translated into innovative practice which would in turn be modeled for future teachers. Goodlad (1984) wrote:

For Seymour Papert and others abreast of this technology, the relationship between child and computer in today's classroom is akin to the relationship between child and pencil in yesterday's. Except that it scarcely exists. Our world is being transformed by the extraordinary capability of this most versatile of man-made tools. But for most of us, including our children whose world will be transformed even more as they become adults, this ongoing revolution, with its accompanying transformation of the economy, communications, and even social relationships, is largely a secret. The almost complete failure of the schools in our sample and of schools generally to open up this secret directly reflects the ignorance and lack of foresight of the surrounding society. There are, fortunately, some contemporary signs of change. (p. 228)

Goodlad, of course, was speaking of what is happening in the primary and secondary grades. We think the same could be said for teacher training programs, especially when it comes to using new technology to change the teaching and learning process.

What seems to be happening in teacher training programs is the same thing that is happening in most public schools. Computer enthusiasts are talking to computer enthusiasts. Johnson (1990) has described an experience where he traveled to a city he had never visited to conduct a university extension course for teachers. At the first class meeting, he was impressed by the wealth of knowledge the students had and the extent to which they were using computers in their classrooms. As the course continued, however, Johnson discovered that he was talking to the dozen most ardent computer enthusiasts in the district. On further investigation, he discovered that outside of these few teachers, almost nothing was happening with computers in the district.

Similarly, we have a hunch that the same thing would happen if we were to visit most teacher training programs in the country. If we walked into the computer lab and spoke to the faculty member in charge, we would immediately be impressed by this person's knowledge and enthusiasm. If, however, we randomly visited several teacher training classes we would find, in too many cases, the same old curriculum being presented in the same old format, and the only exposure to computer technology the prospective teachers were receiving was in the computer lab with the resident computer enthusiast.

To test our hunch, we conducted an informal survey, through which we discovered that roughly 85% of the teacher training programs in the US have a computer lab and offer at least one course in educational computing and/or educational technology. Only about 50% of the teacher training programs, however, have a required course for all teacher education majors. We estimate that fewer than 5% of the teacher training programs have integrated technology into the teacher training curriculum. We can conclude from this that there is almost no actual modeling of the use of technology in teacher training programs. Those future teachers who are receiving some training in technology are receiving it in a very isolated manner. They are interacting with one or more professors, who are computer enthusiasts, with little or no opportunity to transfer their new found skills and knowledge into content and pedagogy courses.

One focus of this chapter is to review the current research in technology and teacher education. Such specialized research is extremely sparse, if nonexistent. The research that has accumulated since the beginning of the computer revolution deals largely with K-12 education. While there is some research involving college-level students, the focus has been on software evaluation, attitudes, or effectiveness of computer-assisted instruction. The research has not addressed the critical area of using technology to change how we teach and learn. It is our contention that such research is important, and that it should be the domain of teacher education programs.

While research in educational technology in general is only in its infancy, it has shown that computer applications can be enormously effective in the schools. Roblyer, Castine, and King (1988) performed a meta-analysis of over 80 studies involving computer-based instruction. They acknowledged inherent difficulties in comparing the wide variation of research focuses, procedures, and findings. Because of the lack of commonality, they were also cautious in generalizing across research findings. Yet their conclusions were revealing. At present computer applications for teaching both mathematics and language arts/reading are yielding impressive results. Further, computer applications appear to be effective in teaching higher-level skills. A significant finding in this review revealed that computer applications at the college level were at least as successful as applications at the secondary and elementary levels. In general, there exists a scattering of successful applications across many content and skill areas.

Roblyer et al. (1988) concluded their meta-analysis by emphasizing the need for a great deal more systematic research in the areas of applications in various skill and content areas, computer applications in ESL, word processing use, creativity and problem solving, effects of computer use on attitudes and drop-out rate, and effects of computer use on achievement of males versus females.

The impression one has after visiting the research on computer-based instruction is that an enormous promise exists for transforming teaching and learning. Its realization, however, waits for the animation of the classroom teacher—a classroom teacher who has not yet discovered the way to integrate the computer into the curriculum and the everyday world of the classroom.

Maddux (1989), in addressing the conditions necessary for the integration of the computer in the classroom, put it this way:

More teachers must acquire general [computer] competencies as well as pedagogical competencies before it will be realistic to move toward widespread integration. I believe that state departments of education must require a least one course in computer education, colleges of education must institute their own computer education graduation requirements, and school districts must offer quality inservice programs. (p. 36)

It is the central contention of this chapter that teacher preparation programs have not themselves come to terms with the computer potential for transforming teaching and learning. And as a consequence, they have not integrated this potential into the pedagogical and curricular experiences of their prospective teachers.

It is not enough simply to have the enthusiasts serve as proponents of the computer's instructional promise and make their claims with one

another. The present situation with teacher preparation finds the computer in insular laboratories unconnected to the mainstream of pedagogy and curriculum. It is no wonder that as teachers graduate from their programs, they tend to view the computer as a fascinating machine set by itself along a classroom wall basically unintegrated into the center of classroom life. It becomes a theme in its replication. What we experience as learners we teach as teachers. The possibilities of the computer have not become a central part of the preparation through the teacher training experience.

If we divide our mission in phases, the first phase was certainly one of acquisition and development. In this phase we were occupied with two concerns. First we had to acquire space, hardware, and software. Second, we had to develop courses and establish them as part of the teacher training program. During this phase our students were exposed to computers and became computer literate.

The second phase of our mission, the one upon which we must now embark, should be to integrate technology into the center of teacher preparation. This is not merely an exercise in placing old wine in new bottles. Rather, it is transforming the teaching and learning experience in the teacher training program. It means active exploration of ways to facilitate learning, experimentation with new course delivery systems, collaboration among colleagues of diverse backgrounds and degrees of technological expertise, and modeling of what we discover so that prospective teachers can transfer the processes to their classrooms.

Phase three of our mission will invite an active conversation with public school practice. The world of the public school will connect with what is being developed in phase two. We will provide a way for teachers to loop back to their teacher training programs sharing their problems and successes.

Goodlad (1984) expressed well the disappointment in the progress of harnessing the power of technology in changing education.

We found little use of calculators, computers, or even the earlier forms of electronic aids such as films, filmstrips, and television. The technological revolution appears to be sweeping around schools leaving them virtually untouched, even while purchasing microcomputers is becoming the "in" thing for school districts to do. (p. 340)

Our challenge is to find ways to prevent the revolution from sweeping around our teacher training programs. The antidote to Goodlad's concern is for us, the computer enthusiasts, to break out of the computer lab and infuse the entire teacher training program with our ideas, skills, and fervor. In other words, move from phase one to phase two, and then begin looking ahead to phase three.

We fully recognize the difficulty of affecting these changes in our teacher training programs. The first stage in this change, however, is to have the challenge continually in our minds and practice. And to this end we must invite our colleagues, even the non-enthusiasts, into the enterprise of integration.

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Experimental and Quasi-Experimental Research in Technology and Teacher Education

Kip Tellez

Yarger and Smith (1990) identified five distinct research methodologies typically used in teacher education research: narrative studies, case studies, surveys, correlational studies, and causal/experimental studies. Whereas the use of narrative and case studies (both qualitative in nature) has recently received much attention in the teacher education research literature, this chapter discusses causal/experimental and correlational research methodology. More specifically, this chapter describes and analyzes (a) quantitative, experimental, and quasi-experimental research designs, (b) examples of research in technology using various experimental designs, and (c) the significance of using quantitative, experimental research in technology and teacher education.

In spite of recent criticisms of quantitative research, a good portion of what educators already know about the teaching and learning process is the result of experimental or quasi-experimental research studies. This chapter explores those quantitative research strategies that have proven useful in decades of educational research and argues for their continued use.

Experimental Designs

A true experimental design depends on random selection of participants from the entire population of interest. Having satisfied this

requirement, the experimental design then requires random assignment of participants to either a treatment or a control condition. This initial step should result in two groups that are likely to be more or less similar with respect to the dependent variable (the variable to be measured) prior to the experiment. The treatment is subsequently administered to the experimental condition. If the data obtained from each group are separated by a sufficient distance, and if extraneous variables have been adequately controlled, the researcher can conclude that application of the treatment was responsible for the group differences. This experimental design is often referred to as the *two-randomized-groups design*.

In the social sciences, researchers are often interested in studying abilities or attitudes that are influenced by underlying constructs such as intelligence or personality. In an attempt to reduce the influence of extra-experiment effects, therefore, many researchers prefer the *two-matched-groups design* to randomized designs. In the typical matched-group design, participants are first assessed on an underlying construct (e.g., intelligence, belief system) and matched with other participants who display similar abilities or attitudes. The matched pairs are then divided randomly into either the control or the experimental group; the experimental group receives the treatment, the control does not. The two-matched-groups design controls for pre-existing differences between the experimental and control groups. As a result, the researcher can be more confident that any treatment effects are due to the experiment.

Often, however, the researcher can explore experimental effects more completely by analyzing more than one treatment group. In such cases, the *more-than-two-randomized-groups design* may be used. This design allows the researcher, for example, to randomly assign participants to one of three groups: (a) a control group that receives no treatment, (b) an experimental group that receives a specific treatment, or (c) a second experimental group that receives a different treatment (or a different level of the treatment) than the first experimental group. Commonly analyzed as a one-way analysis of variance (ANOVA) this design has the advantage of testing the effects of more than one kind of experimental effect. At the same time, however, it tends to become more time-consuming and complicated. For example, when more groups are involved, the researcher needs a greater number of participants. Further, the analysis and interpretation of the experimental results may be more complicated.

More complex still is the *factorial design*. Whereas the previous designs are limited to one independent variable, factorial designs allow for experimental manipulation of two or more independent variables. The least complex factorial design involves two levels of two independent variables (a 2×2 factorial design). For example, if attitudes

towards computers in preservice teachers were the dependent variable, the researcher may decide to employ two different types of courses, individualized or classroom instruction (two independent variables), to affect attitudes towards computers. Each type of instruction may be implemented at two different levels—a 4-week or 10-week course. The 2×2 factorial design yields four cell means. The factorial design has the advantage of assessing both treatments and the levels of those treatments and determining any interaction between the different treatments.

Quasi-Experimental Designs

When conducting social science investigations, researchers often face intact groups (e.g., classrooms, college course sections, boy scout troops, etc.) that cannot be easily divided. That is, they cannot be easily "broken up" to allow random assignment to an experimental or control group. For example, it would be rare for an experimenter to be able to convince a school district to rearrange all the classes at a certain grade level for random assignment in order to conduct an experiment. It would be rarer still for a researcher to gather a random sample from the population of all second-grade students in the US for use in an experiment.

It is significantly less complicated for a researcher to introduce a treatment condition (e.g., a new computer text production application) to one classroom and not to another. The results of the students in the treatment group can then be compared to the results of students from another classroom who did not receive the treatment.

Clearly, this type of research design does not lead to the conclusive evidence provided by *true* experimental designs. Because the participants are not randomly assigned to an experimental and control group, there may be important differences between the groups before the experiment begins. In addition, the experiences of each group may differ greatly in the course of the experiment. Hence, the term *quasi-experimental* design is used to describe studies that use an intact comparison group rather than a true, randomly chosen control group.

In their widely read monograph, "Experimental and Quasi-Experimental Designs for Research," Campbell and Stanley (1963) presented 16 quasi-research designs that reduce the confounding (i.e., nonexperimental factors present in one group and not in another) associated with studying intact groups. Perhaps the most commonly used quasi-experimental design is the *nonequivalent comparison group design*.

The nonequivalent comparison design requires that an experimental and a control group be chosen from two intact groups of participants

(e.g., two separate classrooms). For example, if researchers were interested in the effects of a course in the history of technology preservice teachers' attitudes towards computers, they might require junior-level teacher education students to take the course (experimental group) while not offering it to seniors (comparison group).

At the beginning of the school year, each group would be given a survey measuring their attitudes towards computers. During the year, the juniors would take the course. At the end of the school year, both groups would again be administered a survey. If it were found that the juniors' attitudes improved while the seniors' did not, or that the juniors' attitudes improved to a greater degree than those of the seniors, it could be tentatively concluded that the course had a positive effect on attitudes towards computer use.

However, as with the results from any quasi-experimental design, alternative explanations are numerous. For example, perhaps the juniors were also taking a social studies methods course in which the instructor used computer-assisted instruction. The social studies methods course may be responsible for the improved attitudes whereas the history of technology course had no effect. Or perhaps the seniors were too busy worrying about the demands of their upcoming student teaching experience and, therefore, considered technology something that they "didn't want to deal with right now." As a result of their external demands, the seniors' attitudes may not have improved compared to those of the juniors. This scenario suggests that the history of technology course may have had no experimental effect. In short, the results of any quasi-experimental research must be carefully and cautiously interpreted.

Another widely used nonexperimental research design, while not strictly defined as quasi-experimental, is the correlational research design. Using this design, researchers do not generally assign participants to either an experimental or a comparison group. Rather, they choose a measure of interest (e.g., monthly use of computers) and gather data from a diverse sample of participants on variables believed to affect the dependent measure. If certain variables are found to correlate with the dependent measure, the researcher examines the relationship among the variables and may suggest an explanation. For example, if monthly use of computers was found to be correlated with monthly income, the researcher may argue that the more money people have, the more likely they are to use a computer. Of course, the correlation between these two measures does not suggest the conclusion that having money *causes* computer use or that using computers *causes* having money. The researcher is free to suggest any plausible causal relationship. However, because the findings are not experimentally derived, they are typically not conclusive. Thus, the correlational research design is a form of *quasi-experimental* research.

In spite of the uncertainty associated with quasi-experimental designs, such methods offer researchers a tool for studying (and perhaps improving) all manners of social life. In an important qualification of quasi-experimental designs, Campbell (1969) noted that "where randomized treatments are not possible, a self-critical use of the quasi-experimental designs is advocated. We must do the best we can with what is available to us" (p. 411).

In this chapter, the term *self-critical* is used to denote a deep understanding of the theory and previous research in the discipline. Because the findings obtained using quasi-experimental designs are never "air-tight," the researcher must thoughtfully explore alternative explanations for the phenomena found in the data. Without a command of theories connected to the phenomena in question as well as previous research findings, the researcher is likely to overlook alternative explanations and perhaps make conclusions that are false, incomplete, or both.

Examples of Experimental and Quasi-Experimental Research Designs

This section explores several research design examples from the fields of teacher education, technology, and computer-based instruction.

Experimental

Two-randomized-groups design. Stein, Nachmias, and Friedler (1990) examined the effects of two different modes of data collection (traditional laboratory vs. microcomputer-based laboratory) on 92 eighth-grade science students' ability to graph and interpret the results of a boiling-point experiment. Each student enrolled in one of four physical science courses received an equal amount of instruction in both traditional and microcomputer-based laboratories over a 10-week period. At the end of the 10 weeks, the students were randomly divided into two groups. One group was asked to complete a boiling-point exercise using traditional lab equipment while the other group was given the opportunity to use the microcomputer-based lab that was equipped with interface software designed for analyzing temperature change. The researchers found that students in the traditional lab groups had longer set-up times, exhibited more off-task behavior, and drew more accurate graphs than the microcomputer-based lab group.

Although the researchers randomly assigned students to either a treatment group (microcomputer lab) or a control group (traditional lab), they did not seem to satisfy the experimental design demand of

selecting participants from the entire population. Yet, the population of interest in this study was all the students who had received both types of instruction, the basis for the random assignment of groups. The population from which the random samples were drawn could have been increased by having more students receive both laboratory designs. But that would not make the design more "experimental." With such small sample sizes, it is possible that the students in one group (even though randomly assigned) were more scientific thinkers, thus augmenting their ability to conduct the experiment. To control for such a confounding, the researchers tested each student using *Raven's Progressive Matrices* and found that the means of each randomly chosen group were not significantly different.

It may have been easier to conduct this study using a quasi-experimental design. Instead of randomly assigning participants to one of two groups, the researchers could have left the classes intact and provided one with the microcomputer-based lab and the others with traditional lab, then tested each class for differences on the variables of interest (e.g., off-task, graphing accuracy). However, the true experimental design used here produced more conclusive results. The kind of research design represented in this study perhaps points to other creative ways of conducting experimental research in schools and colleges.

Factorial design. Litchfield, Driscoll, and Dempsey (1990) employed a factorial research design to study the effects of presentation sequence and example difficulty on biology students' retention of subject matter. Fifty-five undergraduates, all enrolled in a biology course for nonmajors, were randomly assigned to one of four treatment groups. Each group was to complete a computer-based lesson created to teach parts of the brain and the effect of drugs on the brain. Presentation sequence, either inclusive or adaptive, and the difficulty of the examples, determined either by subject-matter experts or formulae, served as the independent variables.

After completing one of the four computer-based materials, each student was given a test designed to measure retention of the material. The test data were analyzed using a 2×2 factorial design. Results showed that students in the inclusive presentation group scored slightly better than students in the adaptive group. Similarly, the difficulty of the examples did not greatly affect retention scores. Although the differences in the data were not statistically significant, the use of a factorial design allowed the researchers to explore complex relationships among the data and to make more appropriate suggestions for future research.

In this case, the use of a factorial design may have "washed out" differences that might otherwise have emerged using a less complex

research design; however, the results of this study still offered much information. The risk of not finding significant results by utilizing a factorial research design should not be a motivation for employing less complex two-group designs.

Quasi-Experimental Designs

Correlational design. Kay (1990) collected data from 383 preservice teacher education students on their commitment to computers, attitudes towards computers, computer literacy, locus of control, computer experience, and other demographic variables. Using a multiple correlation or regression model (an extension of zero-order or bivariate correlation) to "predict" commitment to computers, Kay was able to determine both the inter-relationships among the variables and the variable that was most closely associated with total commitment to computers. A positive cognitive attitude about computers was found to be most closely associated (i.e., had the highest correlation) with overall commitment to computers. In addition, knowledge of programming, locus of control, and computer experience did not meet a criterion of correlation. It was concluded, therefore, that these variables have little effect on commitment to computers.

Recall that the correlations among these variables cannot be considered causes. Furthermore, correlational studies, no matter how elaborate, are not experimental. Perhaps, they are best used to suggest future research. Kay concluded the study by noting,

The assumption has been made in this study that commitment to the use of computers is directly linked to the acceptance and use of computers in the educational system. However, it has not been empirically tested. [This assumption] could be tested using a pre-post experimental paradigm. (p. 307)

Single group pre-posttest design. Before initiating a special project designed to increase inservice teachers use and understanding of computers, Bauder, Carr, Planow, and Sarnier (1992) measured teachers' attitudes towards (a) the educational use of computers, (b) perceived comfort and knowledge levels, and (c) perceived district level of support and planning. After the project, participants were asked to complete the questionnaire again. The data revealed that whereas the teachers' attitudes towards computers did not significantly improve, their perceptions of their computer skills improved significantly.

Although this experiment leaves unanswered many questions about causality (e.g., "How can one be sure that the gains in computer skill were not the result of other factors?"), the constraints of imple-

menting the project did not allow the researchers to conduct a complete experiment. The authors were careful not to overstate their conclusions. While the conclusions in all quasi-experimental research must be carefully discussed, the researcher who extrapolates from the results of a single-group design must be particularly cautious and tentative. If possible, the results of single-group studies should serve as a starting point for true experimental research, rather than be considered an independent, conclusive investigation.

Nonequivalent-comparison-group design. Williams, Copley, Huang, and Bright (1992) examined experienced teachers' classroom implementation of calculators. Two intact groups of teachers were studied. The experimental group consisted of teachers, chosen by their district as curriculum writers, who developed, in cooperation with the faculty from a local university, a set of curriculum guides for using calculators in the classroom. The comparison group consisted of a random group of teachers from the same district who received some initial training in the use of calculators in the classroom, but who did not participate in the writing sessions. The researchers discovered, among other findings, that the experimental group stressed the use of calculators as a problem-solving tool more often than those in the comparison group. These data must be carefully interpreted. As with the results of any quasi-experimental design, there may be extra-experimental effects responsible for the differences between the experimental and comparison groups.

The Importance of Dependent Measures in Experimental Research

Both quantitative experimental and quasi-experimental designs depend greatly on the use of dependent measures. Like any experimental research, the quality of teacher education and technology research hinges on the success of its dependent measures. Indeed, the success of any discipline is tied to whether or not those working in the field accurately measure the treatment variable. Many social science disciplines are replete with examples of well researched and validated instruments. Psychologists interested in locus of control, for example, do not develop a new scale each time they wish to investigate this personality construct; rather, they turn to Rotter's well validated scale (Rotter, 1966), now some 20 years old. Similarly, teacher educators interested in technology must take care to develop accurate, valid measures that can be used in a variety of settings and studied using many experimental designs.

The Case for Quality Experimental Research in Technology and Teacher Education

Quantitative, experimental research designs have been widely criticized in the past 20 years (e.g., Lincoln & Guba, 1985). Many argue that qualitative, ethnographic research should be the primary tool of the educational researcher. However, a majority of researchers take an intermediate stance, recognizing that some research questions or topics are best explored using qualitative research, whereas others require a quantitative, experimental approach (Howe, 1985; Strauss & Corbin, 1990). Although a complete analysis of the qualitative/quantitative debate is beyond the scope of this chapter (for further discussion of these issues, see, for example, Smith & Heshusius [1985] and Miller & Fredericks [1991]), it is important to note that the entire process of scientific discovery, both qualitative and quantitative alike, has recently been called into question (e.g., Lyotard, 1984). Many philosophers of science argue that what often passes for the truth about the world is really a reflection of who has the power to create the "truth." No category of research can escape this broad critique. Yet, theoretically sound research using experimental and quasi-experimental designs provides perhaps the best kind of investigation when a researcher hopes that the data will "speak for themselves."

The discipline of technology and teacher education will advance slowly if the majority of studies in the field are descriptive in nature. Descriptions of innovative practices are important in the evolution of any frontier discipline like technology and teacher education. However, describing new technology in teacher education will convince but a few without definitive evidence that such technology helps teachers be better educators.

In addition, forums must be available for exploring the effects of technology. For example, at the University of Houston, a teacher education classroom of the future is being developed. In this technology-rich environment, teacher education students will not only use state-of-the-art technology to learn how to use technology in their own teaching, but a large portion of their own education will be offered using the same equipment. Thus, while learning how to teach, students will be gaining the skills necessary to teach using technology. The teacher education classroom of the future offers an environment well suited for conducting experiments on the programs that will be developed there. This kind of venture must become commonplace in teacher education programs. Each teacher education and technology center can explore both common and unique lines of research, allowing different research groups to study similar processes, thereby providing the necessary cross-checking between laboratories that is such a crucial element in any

true science. Those involved within the University of Houston teacher education technology classroom hope that other sites will develop similar laboratories.

As professionals studying technology and teacher education take early steps towards determining which components of teacher education respond favorably to technology and which are best left to other strategies, it would be wise to consider seriously the mistakes of the past. There exists now an opportunity to develop the experimental foundation of a new discipline. While such an opportunity offers an exciting look into the future, it should also demand a critical look at the past.

Many critics of teacher education (most from inside the field) have maintained that teachers' lack of preparation is owing to the poor performance of those who educate them, particularly in the area of research. For example, Applegate, et al. (1977) argued that the very practical categories of teacher education research do not come close to the highly theoretical research traditions in more "respected" programs within the social sciences (e.g., economics, sociology). Indeed, the lack of attention to systematic development of research methodology, more than any other single factor, may account for why teacher education is commonly perceived as a semi-profession. Schalock (1983) and Howsam, Corrigan, Denemark, and Nash (1976) made a similar observation while Shutes (1975) maintained that the absence of any developed theory and the failure of teacher educators to develop one promotes the practice of training teachers by "folk-wisdom" (p. 85). Schalock (1983) was more specific in his argument that the research about how to best train teachers is beset with a number of problems, including inadequate measurement systems and a methodology that has been ill-borrowed from other disciplines. These and other criticisms have led some to call schools of education, in general, and teacher education, in particular, the "slums" of the academic campus (Schweibel, 1985).

These are strong critiques, but they are not without merit. Those who study technology and teacher education now have the opportunity to engage in the kind of research that will result in a broad body of knowledge which will help beginning and experienced teachers become better educators. The data gathered from experimental and quasi-experimental designs can provide the discipline with compelling research findings, many of which will offer ways to improve teacher education. High-quality experimental and quasi-experimental research in teacher education and technology, in concert with a solid theoretical background and a history of where the discipline has been, may correct past errors in teacher education research.

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Survey Research and Content Analysis Research in Technology and Teacher Education

Gregg Brownell

As technology has become a real, viable presence in education, a continually growing number of educators have become aware of the need to educate preservice and inservice teachers in the use of technology in teaching. As each year goes by, more and more schools and colleges of education require their preservice teachers to complete at least one course on computers, technology, and teaching, while more and more inservice teachers return to graduate school to investigate similar topics.

This need provides, for teacher educators concerned with technology, research opportunities which include investigations of a wide range of issues pertaining to technology and teacher education. The research can range from the qualitative to the quantitative and may beneficially employ any of a number of methodologies. Such investigations can serve as the basis for improved course offerings, enhanced student learning, better understanding of the use of technology in instruction, improved understanding of technology as a change agent, and ultimately, increased, successful use in the schools of the best technology and associated instructional strategies available to teachers.

In this chapter, two types of descriptive research—survey research and content analysis research—will be discussed. First, a brief overview of survey research concepts and techniques will be presented, followed by examples of survey research in technology and teacher education. Both strengths and weaknesses of survey research will be cited, and

suggested directions for future survey research will be offered. Secondly, a short outline of content analysis concepts and techniques will be offered, with examples from technology and teacher education research. Directions for future research in technology and teacher education involving content analysis techniques will be suggested in the light of the limitations and benefits of this methodology. Finally, the need for instructors to conduct research in technology and teacher education will be discussed.

Survey Research

Gay (1987) defines a survey as, "an attempt to collect data from members of a population in order to determine the status of that population with respect to one or more variables" (p. 191). Survey research is characterized as descriptive in nature. The results of such investigations provide a view, or description, of a given group's responses with respect to one or more variables. This view may be derived from data gathered at one point in time, or it may be from data gathered over a period of time for purposes of investigating how a group's perception of the variables changes. For example, a study that is aimed at measuring preservice teachers' attitudes toward computers in the schools may require one administration of an appropriate attitude instrument, thus providing the researcher with a picture of his or her samples' views. Another researcher may be interested in how preservice teachers' attitudes towards computers in the classroom change over time. In this case, the attitude instrument (or different versions of the same instrument) might be administered at the beginning and end of the academic year for all junior education students. Comparisons would be made between the results of the two administrations.

Survey research is classified as self-report research — investigations characterized by individuals offering data about their own opinions, attitudes, or experiences. This data may be gathered in a variety of ways. A questionnaire may be designed and handed to subjects to complete, as in the cases cited above, or it may be mailed to subjects. Additionally, questions may be administered to individuals through telephone, or in-person interviews.

As in any research, selection of subjects and design of the questionnaire (instrument) are both important in conducting a successful study. The sample of subjects should, of course, be representative of the population the research wishes to address. Ideally, a random selection of individuals from a defined population will be sampled, although other standard sampling techniques may be acceptable. In some instances the entire population may be used. For example, a survey of the use of technology within a given school or a particular school district

might require that all teachers respond to the survey. Careful selection of subjects, and meaningful justification of the selection process, will help in determining the extent to which the research findings may be generalizable.

Instrument development should be done with care. A careful case needs to be made that the items are valid — appropriate for gathering the data desired. Items on the instrument may be either closed- or open-ended. The purpose of gathering the data, however, is to make comparisons between individuals in the group under investigation, so all data should be gathered in a standard format so that such comparisons can be made. In the case where open-ended items are used, responses will need to be systematically coded so that responses can be compared. Once developed, the instrument should be tested and refined, both as to validity and reliability. Statistical tests such as Cronbach's alpha, or other appropriate tests, can provide some support that the instrument is reliably (consistently) measuring what it is intended to measure.

The process of conducting any type of research starts with deciding on a research question and then matching the question with the appropriate methodology. A question that centers around the description of some variable or variables as related to a particular group would be appropriately matched with survey research methods. Identifying an appropriate sample, and constructing and testing the research questionnaire are the next steps. The questionnaire must then be presented to the subjects for their participation. This is often done through the mail. A letter of explanation regarding the study with a request for the subjects' participation is included with the questionnaire. After the initial mailing, it is almost always necessary to perform subsequent follow-up mailings to encourage nonrespondents to send in a completed questionnaire. A good rule of thumb is that at least 80% of the sample should respond to the survey. If, after one or more follow-up mailings, fewer than 80% respond, it is necessary to get a sample of responses from nonrespondents, perhaps through telephone interviews. This sample will help in determining if the results of the survey would greatly change if the missing subjects had responded. The danger here is that the individuals who do not respond may share some characteristic that will alter the results. In the case of a study such as the one mentioned above, where data was gathered at one point on students' attitudes toward computers in the schools, nonrespondents might share a negative attitude toward computers in the schools and therefore choose not to fill out the questionnaire. Once data are gathered and analyzed, results are presented in a standard research report format.

The strength of survey research is that it can provide a snapshot of opinions and characteristics of groups as well as descriptions of programs, equipment, and so on. If surveys are done at intervals, it can also

provide a way to compare data over time (longitudinally). Survey data can also be used to make comparisons. For example, a comparison might be made between master teachers' perceptions of beneficial computer use and administrators' perceptions.

One possible weakness in survey research is that too often care is not taken in the development of the instrument used. The instrument should be pretested and refined as needed. Another possible weakness is that a sample of convenience is used, rather than a carefully obtained, appropriate sample. Poor response rate is a third area where weakness may appear in survey research. Many excellent resources are available which offer more depth in the coverage of survey research methods. These range from books on research methods in general which contain chapters or sections on survey research (Borg & Gall, 1983; Gay, 1987) to resources dealing specifically with survey techniques (Orlich, 1978; Warwick & Lininger, 1975).

Survey Research in Technology and Teacher Education

The types of descriptive questions survey research can answer can provide valuable insights into issues surrounding technology and teacher education. One set of questions involves what is happening with technology and education in a number of environments, such as elementary, middle or senior high schools, or in colleges or departments of education. Findings in these areas can provide a good basis for making curriculum decisions regarding preservice and inservice computing and technology courses. These decisions often involve areas such as choice of content, hardware and software selection, and instructional methods both used and discussed in the courses. Information about the status of technology education nationally, regionally, and locally can help instructors make sound decisions regarding these areas.

Becker (1990, 1991) reported on the US portion of the 1989 international "CompEd" survey of the International Association for the Evaluation of Educational Achievement. This large-scale, excellently executed survey obtained responses from approximately 3000 teachers (grades 3 through 12), over 1200 school-level computer coordinators, and 1200 principals. Among other findings, the data indicated there had been, from the early 1980s, an increased availability of a variety of software in the schools, but the use of such software was fairly traditional. Also, older computers (i.e., Apple II series) still accounted for nearly 90% of elementary computers and about 60% of high school computers. Further, teachers said that the biggest deterrent to using computers was finding the time to plan how to use the hardware and software well. This was especially true for more complex software and for instructional approaches that may be student-centered, even when

such materials and approaches offer the possibility of improved student performance. Bruder (1989) studied state departments of education to investigate the status of technology education nationally. As part of the findings, the need for continued funding was viewed as most important to ensure the continued growth of educational technology in the schools. Teacher training was another important area needed to assure the continued advancement of technology in the schools. In general, state departments of education appeared to be going forward with plans to continue and expand the use of technology in the schools.

Both of these studies indicated that time and opportunities for teachers to plan and learn are essential for technology to successfully impact the schools. For technology educators, this serves to emphasize the importance of providing, and carefully structuring, computing and technology experiences for both preservice and inservice teachers. Other survey studies are often performed by individual state departments of education, districts, and even individual schools to get a picture of actual computer use and projected needs for both equipment purchases and training. Such surveys can be the basis for institutional planning and staff development, often in conjunction with university technology education faculty who may provide graduate education or inservice training to school faculty.

Survey studies may also help to provide close alignment of the computer and technology education of preservice teachers with the expectations of schools as to incoming teachers. Fratianni, Decker, and Korver-Baum (1990) conducted a study which identified the self-perceptions of student teachers with regard to their skills with technology and compared those perceptions to administrators' expectations of the students as prospective technology-using teachers. While 81% of the student teachers felt that their undergraduate preparation in technology use was inadequate, the administrators held that knowledge of technology was a factor considered in hiring new teachers. Administrators further believed that expanded uses of technology would be emphasized in their schools in the future.

At the college level, a survey of computer use by faculty, as well as use of computers in instruction by faculty can provide the basis for generating a comprehensive computing plan for a college of education (Brownell et al., 1990). The development and implementation of such a plan can directly affect the manner in which preservice and inservice teachers are educated in teaching with technology.

On a national basis, the Educational Testing Service, as part of the National Assessment of Educational Progress, conducted a survey of 24,000 of the nations' third, seventh, and eleventh grade students' computer competence (Martinez & Mead, 1988). As a professionally conducted, large-scale study, it is a model for survey research of this

type, as well as a source of interesting data for teacher educators. Interestingly, computers were found to be used primarily to teach about computers, rather than to teach subject matter areas. Further, there were racial/ethnic differences in computer competence favoring Whites over Blacks and Hispanics. The authors hypothesized that these differences might be due to access to computers, both in school and at home. The study also found that many computer coordinators rated themselves as only mediocre in their ability to use computers and responded that they had only minimal training in the study of computers.

For those responsible for technology and teacher education, it is beneficial to know what topics are being taught in relevant courses throughout the country. This provides a way to compare program offerings as a basis for program planning and course refinement. One project surveyed instructors identified as teaching or developing a first course in computer literacy to education majors (Brownell, 1990). Data were gathered on instructor background, hardware in use, appropriate topics for such a course, and specific software preferences for teaching desired topics. Topics viewed most favorably by respondents included word processing, databases, spreadsheets, developing problem-solving skills, teacher utilities, trends in teaching with computers, software evaluation, computer-assisted instruction, social issues, and research on using computers in education. A second survey on the computer course for education majors (Lintner et al., 1991) investigated such variables as course content, lab component for the course, equipment availability, the course as elective or required, and course trends. Data were gathered from members of the Special Interest Group for Teacher Education of the International Society for Technology in Education regarding institutional offerings. Of the 38 institutional responses, 34 of the institutions required a computer education course for educators. The content areas most commonly taught were computer-aided instruction, word processing, data management, and spreadsheets.

Another area where survey research yields valuable data is in investigating characteristics of preservice and inservice teachers that may affect technology education course content at the undergraduate and graduate levels. Such characteristics will ultimately affect the beneficial introduction of technology into the schools. One such characteristic is attitude toward computers and computer use. The case is often made that students' attitude toward computing and technology will have an effect both on their learning in computing and technology education courses and on their predisposition to teach with and about computers once in the schools. A positive, comfortable attitude about computers in general, and computers in the schools, can be a strong motivator for using computers with children. Anxiety about computers and technology can make it difficult, perhaps impossible, for teachers to successfully integrate technology into the classroom.

Troutman (1991) designed two instruments, *Attitudes Toward the Use of Computers in Schooling* and *Attitudes Towards Personal Use of Computers*. The instruments were used to measure the attitudes of students in an introductory educational computing course and to investigate the relationship between students' attitudes towards personal use of computers and their attitudes towards school uses of computers. Students who had positive attitudes about their personal use of computers also felt positively about the use of computers in the schools. Brownell, Zirkler, and Brownell (1991) investigated preservice teachers' perceptions of teachers as computer users across six characteristics (comfort with the computer, personal adaptability, gender, time spent with people, gaining efficiency by computer use, and programming a computer). On the positive side, some of the stereotypes associated with computer use did not appear. Computer users were not seen as male, inflexible, or devoid of skill in working with people. However, overwhelmingly, students did not view teachers as computer users. If undergraduate students do not define part of the teacher's role as a professional who uses computers, it may be that as new teachers, they will have difficulty in defining technology use as part of what they do in the classroom. This would be especially true if their school environment did not already strongly support the use of technology. For teacher educators, both of these studies point toward the necessity for positive, successful, personal experiences with computers during the preservice years and toward the presentation of the role of teacher as one which regularly encompasses technology use.

The characteristics and expectations of inservice teachers are important in successfully planning educational experiences for teachers integrating technology into the schools. Woodrow (1991) surveyed 92 teachers at two suburban secondary schools regarding their computer attitude, needs, and experience. The premise was that the successful introduction of a computer program into the schools will depend on the program meeting the perceived needs and goals of the teachers. Respondents viewed the use of the computer to retrieve, process, and present information as a high priority. Applications of the computer as a learning tool and the development of programming skills were given lower priorities. Teachers ranked word processing as the primary need for both students and teachers, with administrative uses ranked as second for teachers and the computer as a source of data ranked as second for students. Lieber and Cosden (1989) investigated the views of computer lab specialists and teachers as to (a) the qualifications and roles of lab specialists and (b) the computing lab environments where they work. The lab specialists had considerable experience with computers, but only 25% had a teaching credential even though their roles required management and instructional responsibilities with students

in the labs. Additionally, teachers and lab specialists viewed differently the impact of technology on academics and motivation. Studies such as these provide insights into the population that technology educators hope to affect positively.

Further Directions of Survey Research

In technology and teacher education, the need for further research in a number of areas continues. We continually need studies that update what is happening in, and what is expected of, the schools regarding technology and education. This includes reports of the expectations of teachers, administrators, policy makers, parents, curriculum designers, and concerned citizens such as members of the business community. The Information Age requires facility with technology. We need to track what various groups expect that facility to be in order to better prepare teachers to meet that need. We also need to continually track the competence of students using technology, both to document successes and to plan for improvements in technology education at all levels. Further, we need to continually appraise such variables as types of hardware and software in use, methodologies employed, and resources committed to technology education. Ongoing research in these areas provides teacher educators with good data on which to base critical decisions.

Studies are also needed which investigate characteristics of both preservice and inservice teachers. Further research into attitude is one example, but other characteristics are also important. Brownell, Jadallah, and Brownell (1991) provided an overview of the formal reasoning abilities of undergraduate elementary education students in a computer-literacy-for-educators course. All students in the course were administered an instrument which classified their reasoning abilities according to Piagetian stages. This description of the students' abilities was considered useful in planning instructional experiences with technology for the students. It is interesting to note that at a time when the call is for teachers to use technology to teach problem solving, only 7.5% of these students performed at the high formal reasoning level and 51% performed at the low formal level. The remaining 41.5% did not perform at the formal operations level. This has implications for the education of preservice teachers, and also for the types of experiences they may (or may not) be able to provide to their future students. We need good descriptive research that investigates characteristics such as reasoning ability, learning style, and attitude, as those variables may relate to learning and teaching with technology. A good description of the preservice and inservice population can be the basis for planning other types of research such as experimental studies. For example, the

study cited above on formal reasoning can lead to a series of studies on the development and use in the course of specific strategies and materials to provide students with experiences to develop their formal reasoning abilities.

Another area of interest in technology and education is cooperative learning. The interpersonal skills (and attitudes toward learning) necessary for preservice and inservice students to engage successfully in cooperative learning with technology are probably not present in most students—few students have had the opportunity to develop them. Survey research in this area could provide valuable data for planning instruction necessary to provide successful experiences with cooperative learning and technology for teacher education students.

With solid descriptions of these and other characteristics we can also begin to relate our instructional choices (materials, strategies) specifically to methods and materials in the schools. Many of the characteristics of preservice and inservice teachers about which we need to become informed would also be important to investigate in the K-12 population. If we gain a good description of preservice or inservice students, say in relation to formal reasoning, and then create strategies to help students develop their reasoning skills, similar investigations and adoption of the strategies may be beneficial at other instructional levels. This would aid the successful integration of technology into the schools.

Content Analysis Research

The coverage to this point has dealt with survey research as a type of descriptive research which can be used to look at characteristics of populations (e.g., preservice and inservice teachers) and what is being done, as well as what various groups expect to be done, with technology in the schools. Another type of descriptive research, content analysis, is valuable for gathering data on the materials used in technology education.

Content analysis may be classified as descriptive research which is observational in nature (Gay, 1987). Content analysis is one of several forms of observational research. (Other forms of observational research are addressed in this monograph in the chapter on ethnographic research and the chapter on classroom observations.) Content analysis focuses on the quantitative analysis of the content of any form of communication. In this instance, a communication can be any of a number of materials such as books, journals, pictures, software, transcripts of speeches or interviews, records from computer sessions, videotapes, or videodiscs.

In performing content analysis research, the investigator poses the research question, locates and samples the materials to be analyzed, trains raters to rate the materials on characteristics of interest, has the materials rated by the raters, and evaluates the results. Key to this type of research is the reliability of the raters' decisions. Usually, at least two raters are trained to code characteristics of interest within the materials. In coding, the raters separately rate the materials. Neither rater knows the coding decisions made by the other. If, during training, the researcher finds that the raters initially agree on how materials should be categorized (perhaps 90% agreement on all coding decisions) the analysis of the materials can reliably proceed—the investigator can assume that both raters are categorizing the materials according to the same criteria. If this is not the case, the raters receive more training until acceptable agreement is reached. After successful training, the actual materials in the study are rated. Agreement is then checked again. Raters then meet to arrive at consensual agreement on ratings where they disagreed. These consensual ratings, plus all original ratings of the actual study materials where agreement occurred, are used in the final data analysis.

Content Analysis Research in Technology and Teacher Education

Technology educators at all levels, especially teacher educators, need to be aware of the content of materials which are used in their teaching. Commonly, computer software, videotapes, videodiscs, CD-ROM discs, TV shows, books, magazines, and newspapers are the types of communications used in technology education. The topical content in such communications must be both accurate and nonstereotypical. Presentation of material that is stereotyped may lead to the perpetuation of the stereotype. This can have negative effects for some groups within our society. For example, females presented with books, computer software, magazines, and television shows that constantly portray the computer as a white male domain may, when these influences are combined with others in society, choose to distance themselves from experiences with computers and technology. This can lead to a loss of opportunity for individuals and the loss to society of a prospective talent pool.

As teacher educators we need to be aware of the underlying messages in the materials we use. Content analysis is a technique which can be used to uncover those messages. Ware and Stuck (1985) looked at sex role messages in computing magazines and found women both under-represented and presented in stereotypical roles. Brownell and McConaughy (1990, 1991) looked at the representation of women and

minorities in computer clip art and found both groups to be significantly under-represented compared to what would be expected according to population figures. Brownell (1992) investigated the representation of females in computer education texts grades K-12 and found that females were under-represented in positions of power, under-represented as active computer users, and over-represented as passive in relation to the computer. Investigations of this sort can alert teachers and teacher educators to issues that need to be addressed in the materials they use. Instructors can then deal with the issues in class, modify materials, and alert publishers to needed changes. Another valuable area for investigation is how computing and technology is portrayed in other content areas. A case can be made that teacher educators in other content areas (mathematics, reading, language arts, etc.) need to provide instruction on using technology in their methods courses. Jurkovic (1991) investigated the coverage of computer topics in reading methods textbooks published between 1988 and 1990. He found coverage to be minimal.

Content analysis can also be used to assess success in curriculum change. Scherer, Brownell, & Brownell (1992) used a content analysis of childrens' pictures to infer childrens' understanding of and comfort with computers. One indication is that children with teachers who provide more extensive computer experiences may tend to identify themselves as computer users in pictures they draw, rather than identify others as computer users. Such findings can support the effectiveness of technology instruction in the schools and might also be the basis for experimental studies to link specific content and teaching practices with the development of such student perceptions. Once identified, successful practices and content can then be used as topics in technology and teacher education courses.

The major strength of content analysis research is that it can provide a systematic, quantitative analysis of materials. By carefully defining the characteristics to be investigated, a reasonable picture of those characteristics in the materials under study can be drawn. Two major weaknesses are prone to occur in content analysis; low interrater reliability and inadequate sampling. To avoid low reliability, use of at least two raters who have been carefully trained is essential. It is also essential to report interrater agreement on initial observations, by using an appropriate statistic such as Cramers V, or at least by reporting percent of initial agreement between the raters. If interrater reliability is low, results of the study may be useless. To avoid inadequate sampling, selection of materials truly representative of all materials available must be accomplished. For example, a study of content covered in high school computer information systems texts would ideally require a random sample drawn from all texts available at the time of the study. For a number of reasons, this may not be possible to achieve, and thereby the generalizability of the study is weakened.

Further Directions of Content Analysis Research

We need more content analysis studies of the materials we use regarding stereotypes present in the materials. As technology becomes more powerful for presenting content, we need to be sure content is fairly presented. A colleague related an experience of reviewing interactive videodisc materials from a major manufacturer who had actively tried to avoid stereotypes in the materials. As the package was viewed, the colleague noticed fair representation of females in the workplace. Further into the package, however, were scenes that took place in a home setting. In every instance, the portrayals at home were stereotypical!

Specific, isolated instances of stereotypical representations in software, books, and other media may seem of minor concern. However, when these instances are added together and then added to other societal signals, stereotypes with negative results form. We need studies of images in software, multimedia, books, television shows and so forth, and we need to use that data to alert publishers and teachers. Although not mentioned to this point, we also need content analyses of the themes present in these materials. Themes should be available in media which appeal to all areas of our population, not just to an isolated segment.

More research is also needed on the technology content of texts used to teach other areas of teacher education such as methods courses. We need to establish good baseline data and begin to track what computer topics make their way into such courses. Beyond texts, analyses of syllabi for these courses would be valuable. Even if relevant topics do not yet appear in the methods texts, the topics may still be taught in the courses. Perhaps methods instructors supplement texts with their own, or other, material. Once baseline data are established, ongoing research in this area can provide a picture of how the computer-related content of these courses changes over time. We need these data to make decisions about course content in technology and teacher education courses, and also to gauge the extent technology is being used with future teachers before they get to the schools.

Studies of K-12 schools' computing and technology curriculum documents as compared with curriculum documents in teacher education programs would be valuable for purposes of aligning the two curricula. Also, analyses of student work at the preservice level, such as content analyses of journals kept throughout the semester of a computer literacy course, could aid in evaluating course content, student concerns, and student learning.

Conclusion

As technology and teacher educators, we need more research on what is happening in the schools with technology. Curriculum profiles,

methods employed, resources committed, faculty training, and equipment used are all important areas open to investigation by survey techniques. Further, we need good descriptions of the populations we work with, preservice and inservice teachers, as to characteristics of those populations that may affect our course development and teaching methods. We also need to investigate characteristics of those populations that may have an effect on the integration of technology into the schools once teachers are placed in classrooms where technology is available. Survey research can provide data on these types of questions. Further, we need careful content analyses of the materials used in technology education. Such analyses can investigate possible bias or stereotypes in materials ranging from software to books to videodiscs. Finally, an ongoing line of research to investigate documents that present topical coverage in other education courses—and in the schools—can also help to align our teaching with topics perceived important at other levels. This type of content analysis can yield reasonable data for decision making in program development at all levels.

Teacher educators in general, and technology and teacher educators in particular, can contribute a great deal to education. One way of making that contribution is by carefully asking important research questions and carefully designing and conducting studies to answer those questions. Survey and content analysis research are two methods that can be used to accomplish that.

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Meta-analysis in Technology

Yuen-Kuang Liao and George W. Bright

This chapter focuses on the types of research questions that might be answered by using meta-analysis in the area of technology and teacher education. The chapter is divided into three parts: (a) description of the meta-analysis research method, (b) examination of meta-analyses dealing with technology, and (c) discussion of the use of meta-analysis in the area of teacher education and technology.

The Meta-analysis Research Method

Definition of Meta-analysis

Research syntheses using meta-analytic methods have made the 1980s an extraordinary time in the history of research on teaching. Cooper (1984), Glass, McGaw, and Smith (1981), Hedges and Olkin (1983), Jackson (1980), Light and Pillemer (1982), Rosenthal (1976), and Hunter, Schmidt, and Jackson (1982), among others, provide excellent examples and insights on the use of meta-analysis on teaching and learning. Meta-analysis was first advocated by Glass (1976); the primary purpose of meta-analysis is "the statistical analysis of a large collection of analysis results from individual studies for the purpose of integrating the findings" (p. 3). Since 1976, literally hundreds of reviews have been conducted using meta-analysis research methods, with many other papers also presenting refinements of the methodology (Hedges, 1987, p. 353).

For years, there have been different views regarding what exactly constitutes a meta-analysis. Bangert-Drowns (1986) categorized five

forms of meta-analytic methods: Glassian meta-analysis, study effect meta-analysis, combined probability method, approximate data pooling with tests of homogeneity, and approximate data pooling with sampling error correction. These meta-analytic methods differ in terms of the purpose of review, unit of analysis, treatment of study variations, and outcome of analysis. However, all of the techniques apply statistical methods to the treatment of quantitative representations of study outcomes. This distinguishes meta-analysis from traditional and more informal narrative forms of review such as "vote counting" or "box-score" reviews.

Procedures for Conducting a Meta-analysis

In all types of meta-analysis, the basic procedures include (a) locating studies of an issue through objective and replicable searches, (b) coding the studies for salient features, (c) describing studies' outcomes on a common scale, and (d) using statistical methods to relate study features to outcomes (Kulik, Kulik, & Bangert-Drowns, 1985). Wolf (1986) highlighted 13 guidelines for the practice of a meta-analysis.

1. Define and report criteria for the inclusion and exclusion of studies.
2. Search for unpublished studies in order to test type I error.
3. Develop coding categories to accommodate the largest proportion of the identified literature.
4. Examine multiple independent and dependent variables separately through blocking mediating effects.
5. Examine and graph the distribution of results and look for outliers to examine more closely.
6. Check the reliability of raters who code study characteristics.
7. Always accompany combined tests of significance with estimates of effect size.
8. Calculate both raw (unadjusted) and weighted combined tests and effect sizes to empirically examine the impact of sample size on results.
9. Consider whether it is important and/or practical to calculate nonparametric as well as parametric effect size estimates.
10. Consult the literature on meta-analysis for guidance when in doubt.
11. Combine qualitative reviewing with quantitative reviewing.
12. Describe the limitations of your review and provide guidelines for future research concerning relationship reviewed.
13. Remember Green and Hall's (1984, p. 52) dictum: "Data analysis is an aid to thought, not a substitute."

Obviously, there is a lot for a researcher to remember while conducting a meta-analysis. However, the potential payoff is significant.

Advantages of Meta-analysis

There are a number of potential problems with a traditional literature review. These include (a) selective inclusion of studies often based on the reviewer's own impressionistic view of the quality of the study, (b) differential subjective weighting of studies in the interpretation of a set of findings, (c) misleading interpretations of study findings, (d) failure to examine characteristics of the studies as potential explanations for disparate or consistent results across studies, and (e) failure to examine moderating variables in the relationship under examination (Wolf, 1986).

In contrast, meta-analysis has been viewed as an efficient way to summarize large literatures (Green & Hall, 1984), while providing several distinct advantages over traditional methods of synthesis (Hauser-Cram, 1983; Jackson, 1980). First, it is a systematic, clearly articulated, and replicable approach to integrating findings from a set of studies. Second, because quantitative aggregation of effects or studies enlarges sample sizes and, in turn increases power, patterns of relationships can become apparent and the probability of detecting an effect, even a small one, is increased. Third, reviewers using meta-analysis can present a fairly comprehensive picture of results over a large range of subjects, programs, times, and research methods. Information from the best and less-than-the-best studies can be included, with controls for possible biases caused by various flaws in the available studies. Fourth, meta-analysis provides reviewers with a method which is especially responsive to certain types of questions. Broad questions about the general effectiveness of a certain program or treatment can be addressed, even to the point of determining estimates of population parameters. But beyond these broad assessment questions, meta-analytic techniques can be employed to investigate systematically the relationship between a large range of descriptive variables and outcome measures.

Several researchers (Green & Hall, 1984; Light & Pillemer, 1982; Wolf, 1986) have suggested that meta-analysis is helpful in highlighting gaps in the literature, providing insight into new directions for research, and finding mediating or interactional relationships or trends either too subtle to see or that cannot be hypothesized and tested in individual studies. In general, meta-analysis offers reviewers advantages over other methods of synthesis that are similar to the advantages gained by primary researchers who have the opportunity to move from a small pilot study to a large-scale investigation in which there is a large sample

and a wide range of subjects and measures (Hauser-Cram, 1983). Meta-analysis "is an important contribution to social science methodology. It is not a panacea, but it will often prove to be quite valuable when applied and interpreted with care" (Jackson, 1980, p. 455).

Criticisms of Meta-analysis

Just like any other research methods meta-analysis has not been free from criticism. Critics of meta-analysis have found fault with techniques and features that are characteristics of this approach. For example, meta-analysis can only assess relatively direct evidence on a given topic, and it is perhaps difficult to achieve valid and reliable coding of the characteristics of the primary studies to be analyzed. In addition, when the available studies for a given topic are few in number and their results are relatively heterogeneous, the findings of a meta-analysis may mislead our understanding of the given topic. These same concerns, however, could be addressed to traditional forms of reviews. More substantial concerns that have been raised can be grouped into four categories (Cook & Campbell, 1979; Glass et al., 1981; Wolf, 1986; Wortman, 1983):

1. Logical conclusions cannot be drawn by comparing and aggregating studies that include different measuring techniques, definitions of variables (e.g., treatments, outcomes) and subjects because they are too dissimilar.
2. The inclusion of methodologically poor studies in the review can result in uninterpretable results in meta-analysis.
3. The representation of individual studies by multiple effect sizes can result in nonindependent data points, and misleadingly large samples.
4. The selection bias in reported research can lead to biased meta-analysis results.

Improvements in meta-analysis techniques have answered some of these criticisms, but it remains up to the researcher preparing a synthesis to determine whether the advantages of the meta-analysis technique outweigh the disadvantages for the particular area under investigation. In general, our view is that meta-analysis techniques add considerably to our understanding of phenomena related to teaching and learning.¹

Meta-analyses about Technology in Education

Researchers have used meta-analytic techniques to synthesize the effectiveness of varied technology on human learning for more than a decade. Since 1978 many meta-analyses have been done, including those in which new technology such as computer-based instruction and

interactive videodisc instruction was compared with conventional classroom instruction. However, very few of the analyses have given any attention to teacher education. In this section, therefore, a brief review of meta-analyses of technology in education is presented.

Walberg and his colleagues at the University of Illinois at Chicago have completed a series of meta-analyses regarding the effects of technology in education. Three meta-analyses were specifically related to the effectiveness of computer-based instruction at varied school levels (i.e., elementary or secondary) and with exceptional children. The mean effect size (ES) for the meta-analysis conducted for the elementary school level (Niemic, Samson, Weinstein, & Walberg, 1985) was 0.45, suggesting that the computer-assisted instruction (CAI) has positive effects over conventional instruction on students' achievement. A review of CAI for secondary school level showed a slight positive effect of 0.32 favoring CAI (Samson, Niemic, Weinstein, & Walberg, 1985). Finally, a meta-analysis for special education children yielded stronger positive effects of 0.56 favoring CAI (Schmidt, Weinstein, Niemic, & Walberg, 1985). Overall, the results of these meta-analyses indicate positive effects of CAI over conventional instruction on students' achievement across varied school levels and educational programs.

Chen-Lin and James Kulik and their colleagues at the University of Michigan also conducted a series of meta-analyses for technology in education. Their studies focused on the effects of various educational technology (e.g., audiotutorial instruction, computer-based instruction, and programmed instruction) on students' achievement. The mean ES for the meta-analysis on audiotutorial instruction (Kulik, Kulik, & Cohen, 1979) was 0.20, suggesting that audio-tutorial instruction has slightly positive effects over conventional instruction on students' achievement. For the meta-analysis of programmed instruction (Kulik, Schwalb, & Kulik, 1982), the mean ES was 0.08, indicating there were only trivial effects of programmed instruction on students' achievement. Several meta-analyses of computer use on students' achievement (Kulik, Kulik, & Bangert-Drowns, 1985; Kulik, Kulik, & Cohen, 1980; Kulik, Kulik, & Schwalb, 1986) studied grade levels ranging from elementary school to adult. The type of computer use in these syntheses included CAI, CEI (computer-enriched instruction), and CMI (computer-managed instruction). The mean ESs of these meta-analyses were 0.47, 0.25, and 0.42 for elementary, college, and adult students, respectively. These meta-analyses demonstrate a typical learning advantage for computer use on students' achievement over conventional treatments.

Liao and Bright (1991) and Liao (1990) studied the effects of CAI and computer programming on students' cognitive outcomes (e.g., conceptual transfer, conditional thinking skills, critical thinking skills, metacognitive skills, and problem-solving skills). There was a medium

positive effect of CAI and computer programming on students' cognitive outcomes, with mean ESs of 0.48 for the CAI, 0.41 for computer programming, and 0.44 for combined CAI and programming. Overall, these meta-analyses suggest that teaching and learning CAI and computer programming have some learning benefits on students' cognitive outcomes.

Meta-analysis about Teacher Education and Technology

Very little "meta-analytic attention" has been given to the area of technology and teacher education, perhaps because this is a new field in educational research and there may be not enough literature available to conduct such analyses. The first step in the process, however, would be to conduct a thorough and systematic search of literature to determine if there are adequate studies to form the "data" for a meta-analysis. This determination would have to take into account appropriate criteria for inclusion or exclusion of specific studies; for example, what kinds of technologies would be acceptable?

One of the clear advantages of using the meta-analysis technique in technology and teacher education is that the coding of the studies could account for many different variables, so that a variety of interesting research questions could be investigated. For example, there are many different uses of technology (e.g., videotaping, computer simulations of classrooms, simulations of diagnosing learning difficulties) that have been employed to try to help people become better teachers. Analyses of the ESs could assist researchers in comparing the relative effectiveness of these uses. Also, comparisons could be made among differing technological backgrounds of teacher education students. We might find out whether students who are technologically literate are effected more by the use of technology in their teacher education program than students who lack technological literacy. Further, meta-analysis would permit investigation of the effects of the degree of consistency between the technological environment in a university and the technological environment in the schools used as laboratory settings. Also, technology may influence some outcomes of teacher education programs more than others (e.g., questioning behavior, classroom management, understanding of children's thinking). A meta-analysis might help identify these areas. The reader can undoubtedly pose other questions in the area of technology and teacher education that might be better answered by a meta-analysis than by other traditional synthesis techniques.

Certainly some, and perhaps many, of the interesting questions cannot be answered at this time, simply because there are not an adequate number of studies related to some critical variables. Knowing where these gaps are could influence the direction of future research on

technology in teacher education. Merely counting the number of studies is likely not to identify all of the gaps; it is only when all of the important variables are coded for all available studies that the gaps will clearly appear. Identifying the important variables and beginning the task of creating a database of coded studies would appear to be the most important tasks to begin immediately.

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Note

¹ For further understanding of meta-analysis, the following are useful methodology writings: Cooper (1982), Glass (1977), Glass, McGaw, and Smith (1981), Hedges and Olkin (1981, 1983), Jackson (1980), Light and Pillemer (1982), and Walberg (1986).

Ethnographic Research in Technology and Teacher Education

Dianne Novak-Aitken

Conducting research in the area of teacher education and technology is a complex process. It requires careful investigation of a variety of interrelated people, systems, and entities, including teacher educators, future teachers, experienced teachers, educational administrators and policy makers, K-12 schools and classrooms, teacher preparation programs, computers and other hardware, software, school cultures, and so forth. Each of these aspects associated with the fields of technology and teacher education is dynamic and vital and interacts with the others in infinite and often unexpected ways. Understanding these relationships and their interrelated effects calls for research methods which allow for careful, broad-based examination of the relevant issues. Qualitative research methods provide such a means for exploring and understanding the complex interactions of technology use and teacher education by developing a holistic perspective of the situations or questions at hand. As suggested by Erickson (1986), these methods are highly applicable to the investigation of the specific nature of occurrences and the perspectives of particular actors in particular events rather than to the examination of the general character and overall distribution of isolated variables.

Although qualitative methods have long been

"the staple of certain social sciences, notably anthropology, history, and political science, . . . more and more researchers in fields with traditional quantitative emphasis (psychology, sociology, linguistics, public administration, organizational studies, urban planning, educational research, program evaluation, and policy analysis) have [now] shifted to a more qualitative paradigm" (Miles & Huberman, 1984, p. 15).

Much of this paradigm shift is due to the realization that qualitative methods provide a way to understand complex social phenomenon, such as technology use and the preparation of future teachers, with greater clarity and detail than afforded by other methods.

Qualitative methods are a source of well-grounded, rich descriptions and explanations of processes occurring in local contexts. With qualitative data, one can preserve the chronological flow, assess local causality, and derive fruitful explanations. Then, too, qualitative data are more likely to lead to serendipitous findings and to new theoretical integrations; they help researchers go beyond initial preconceptions and frameworks. Finally, the findings from qualitative studies have a quality of "undeniability," as Smith (1978) has put it. Words, especially when they are organized into incidents or stories, have a concrete, vivid, meaningful flavor that often proves far more convincing to a reader—another researcher, a policymaker, a practitioner—than pages of numbers. (Miles & Huberman, 1984, p. 15)

While these methods are becoming increasingly accepted and used in the investigation of educational issues, there is often confusion concerning what is meant by "qualitative" research. Different researchers, for example, frequently employ various techniques when conducting qualitative research and there is no clear definition of what constitutes this methodology. Strauss and Corbin (1990) suggest that it is "any kind of research that produces findings not arrived at by means of statistical procedures or other means of quantification" (p. 17), and that the data are presented in a manner that allows "the informants to speak for themselves" (p. 21). Bogdan and Biklen (1982) contend that qualitative research focuses on understanding behavior from the subject's perspective. Patton (1987) offers general themes which can be used to identify qualitative research. For example, qualitative research is naturalistic in that there is little attempt to manipulate the circumstances or participants, and conducting this type of research generally causes the researcher to have close and direct contact with the situation under study. Further, qualitative research is oriented toward exploration, discovery, and inductive logic. Most important, however, qualitative research is designed to understand situations as a whole and from the perspective of the players involved.

Currently, there are many approaches to conducting qualitative research; among them are: grounded theory generation; life histories; biographical; conversational analyses; case studies; phenomenology; and ethnography. Each of these specific methods has its own advantages and disadvantages and is best suited to certain types of research situations. These varied approaches are often used in combination with one another even though some of them are based on very different

philosophical foundations. Although each of these methods is useful and readily applicable to inquiries associated with technology and teacher education; the remainder of this chapter will focus only on the use of ethnographic methods in this domain.

Features of Ethnographic Research

Wolcott (1988) suggests that ethnographic research methods are particularly well suited to answering the question of "What's going on here?" Investigations of technology use and teacher education are intricately tied to this question because they seek to understand individual teachers and teacher educators, their personal instructional decisions, and their unique classroom cultures as related to technology use. That is, they explore what is going on inside individual teachers' heads as well as what is going on in particular classrooms.

In general, ethnographic research efforts seek to understand the culture of a particular group of people, to study human behavior in terms of its cultural context. Culture encompasses what people do, what they know and believe, the things they make and use, their patterns of behavior, and their knowledge base. A particular culture may be large, such as one associated with a particular ethnic population, while another culture may be microscopic in comparison, such as the culture of an individual classroom. The idea of culture, however, is central to ethnography and the underlying assumption guiding ethnographic inquiry is that every human group that is together for a period of time will evolve a culture (Patton, 1980).

This focus on culture is steeped in the tradition of anthropology. Agar (1986) points out that although traditional anthropologists typically study remote and nonliterate cultures, many modern anthropologists apply their methods to contemporary society and its problems and issues. The core of anthropological methods in the tradition of anthropologists is participant observation of the culture under investigation. In this tradition, the researcher becomes immersed in the field, and as Spradley (1979, 1980) suggests, learns from the members of the culture rather than merely learning about them.

Since the cornerstone of ethnographic research lies with immersion by the researcher into the culture of study, this makes the process both labor-intensive and time-consuming, and places the investigator in a unique situation. For instance, a key role of the researcher in this type of study, according to Glaser and Strauss (1967), is to be a "highly sensitized and systematic agent" (p. 251). The researcher is the primary research "instrument" (Guba & Lincoln, 1981; Woods, 1986), and is undeniably biased in certain, even natural and expected, ways. Bias is, for example, "represented in the commitment to conduct the study in

the first place, to examine one set of events instead of some other, and to analyze results thematically rather than statistically" (Barritt, Beekman, Bleeker, & Mulderij, 1985, p. 63). Agar (1980) points out that it is not a question of whether the ethnographer is biased, but how the biases can actually enhance the research process.

Since the researcher is his or herself the instrument, changes result from fatigue, shifts in knowledge, and cooptation. But this loss in rigor is more than offset by the flexibility, insight, and ability to build on tacit knowledge that is the peculiar province of the human instrument. (Guba & Lincoln, 1981, p. 113)

Although traditional ethnographic research is based on the researcher's commitment to spending time "in the field," it typically remains difficult, if not impossible, to investigate an entire population of the culture under inquiry. Rather, "purposeful sampling" (Guba & Lincoln, 1981; Patton, 1980, 1987) is generally used to select participants (or key informants) who are "information rich" (Patton, 1980, 1987) and can provide in-depth, detailed information pertinent to the questions at hand. Fielding and Fielding (1986) posit that the use of informants is "absolutely necessary" to the investigation of complex situations because the observer cannot possibly be everywhere at all times. Spradley (1979) suggests that a "good" informant is one who (a) knows the culture well, (b) is currently involved in the culture of interest, (c) provides the researcher with an unfamiliar cultural scene, (d) has adequate time, and (e) is nonanalytical.

In general, ethnographic researchers rely on three main types of data collection methods: interviews, observations, and written documents. Each of these is a critical part of the data collection process and provides insight into various aspects of the culture.

Interviews are a central part of ethnographic research because they allow understanding of others' perspectives by attending to what they say. That is, interviews provide opportunities to discover what is in someone else's mind. Further, interviews are a way to develop an understanding of the language of the culture and to discover the meanings which participants attach to certain events and items. Although a variety of interviewing styles can be employed, ethnographers generally rely on open-ended, in-depth interviews, those similar to natural conversations. Spradley (1979) compares ethnographic interviews to a series of friendly conversations. This type of interview is spontaneous, flexible, and ever-evolving to allow the exploration of new and unexpected topics.

Observations, particularly participant observations, are a second major aspect of ethnographic research. These observations, which occur in the field, allow the researcher to develop a holistic understanding of

the culture at hand. Observations also permit the researcher to go beyond the memory and perceptions of others to experience the culture him or herself, which may uncover important information which informants take for granted or otherwise fail to reveal. The first-hand knowledge and awareness gained through participant observation encourages reflection on the part of the researcher and promotes the discovery and inductive nature of this type of research.

A third source of information for the ethnographic researcher is written documents. These may be archival documents, such as correspondences, budgets, charts, lesson plans, or grade books. Documents may also include those specifically created for the on-going inquiry, such as logs or diaries maintained by specific participants at the request of the researcher. In addition, the researcher's fieldnotes are a vital part of the written documents which play a part in the data collection and analysis process. Fieldnotes describe what the researcher has seen and heard while in the field as well as her comments or initial interpretations about these observations and conversations.

Using these three different methods of data collection, also known as triangulation, enhances understanding, builds credibility, strengthens confidence, and increases validity of ethnographic research. The information gathered through one method can be compared to that collected using alternative methods, and weaknesses in a particular method can be overcome by the use of others. Along with the use of various data collection methods, triangulation can be achieved through the use of different data sources, such as various informants. Another way to increase the credibility of an ethnographic study is to have the informants validate the analysis to be certain that key points are accurately perceived by the researcher.

Analysis of the data collected through ethnographic methods can be completed through a variety of techniques, such as domain analysis (Spradley, 1979, 1980), constant comparative analysis (Glaser & Strauss, 1967), matrix development (Miles & Huberman, 1984), and content analysis (Patton, 1980). Often, data analysis occurs simultaneous to the data collection process. Miles and Huberman (1984) point out that there are few agreed-upon rules for analyzing the data and verifying the findings in this type of research effort. In a general sense, the data analysis is an inductive process of generating hypotheses from the data rather than beginning with hypotheses and testing their validity. However, besides the generation of theories or hypotheses, data analysis can focus on the development of "rich descriptions" or on understanding of specific incidents through the identification of common patterns or trends which appear in the data. The specific data analysis process used may vary according to the particular research issues, the purpose of the study, and the type of data. In any case, the data analysis process is time-

consuming and requires careful attention to the details and patterns contained in the massive amounts of data. The typical process of data analysis involves the following steps: (a) review and tentatively organize the raw data, (b) search for tentative patterns and identify trends and linkages in the data, (c) reorganize the data according to what fits together and provide support through the use of quotes and examples, and (d) review the data again to seek disconfirmation of findings through the identification of rival themes.

The final step in the research process is to document and distribute the findings. Ethnographic research reports often take the form of descriptive passages which share the meaning of the culture as viewed by the participants to outsiders. Other formats for ethnographic write-ups are also used, such as those which outline any theories uncovered or suggest future research avenues.

Using Ethnographic Research in the Study of Technology and Teacher Education

Ethnographic methods can serve a variety of functions related to research issues of technology and teacher education. For example, careful study of the practices of experienced classroom teachers' and teacher educators' computer use provides valuable information regarding the computer-related preparation of future teachers. Specifically, how do classroom teachers use technology to facilitate the teaching and learning processes? How does this technology use impact their role of the teacher and their relationships with the learner? Ethnographic methods are one way of investigating and understanding the intricate workings of the classroom environment, including the impact of computers on the individuals in that environment. Inquiries which examine the relationships between teacher and computer, student and computer, and computer-using teacher and computer-using student are needed to better understand the impact of technology use on the teaching and learning processes. Examining the use of specific instructional software or the implementation of certain instructional methods using the computer may reveal insight into "what works" in a typical classroom environment. Are certain programs more easily integrated into the standard classroom? Do some types of software better lend themselves to use by certain types of teachers or students?

Research reports which include descriptive details of technology use in K-12 instruction can promote educational change by providing other educators with realistic examples of technology use upon which they can build. These types of reports can be used to answer the questions related to "how" can computers be used in the instructional process? Teacher educators can use this kind of information as a source

of ideas for integrating technology into their own teaching as well as a way to keep up with current classroom practices. This provides them with opportunities to model technology use and to otherwise share ideas with the preservice teachers for whom they are responsible for preparing to teach in tomorrow's schools. Teacher educators can demonstrate ways in which technology is being used – both successfully and unsuccessfully – and also suggest ways to expand or improve upon the uses found in typical classrooms.

Another use of ethnographic research is to explore technology use in teacher education programs. This could be conducted as a follow-up study to determine how graduates implement technology upon leaving the teacher education institution and entering the classroom as a teacher, thus examining the transfer of teaching skills—specifically those related to teaching with technology—from the teacher preparation environment to the classroom by beginning teachers. Does learning about technology in the teacher preparation program impact later computer use by the classroom teacher? Further, what effects do field experiences in technology-using classrooms have on the emerging teacher's attitudes and behaviors toward teaching with computers? Many teacher preparation programs provide few experiences for the preservice teacher to interact with technology during formal coursework. Yet, many of these same teachers are entering field placements which are rich in technology use. How does this impact the beginning teacher's own technology use? Or, what about the beginning teachers who have seen, heard about, and experienced technology use throughout his or her formal teacher preparation and then enters a "technology-barren" environment? Does that teacher seek out ways to locate and use technology? Questions such as these which examine the relationships between teacher preparation experiences and later teaching behaviors are well suited for investigation using ethnographic research methods.

Ethnographic methods could also compare technology usage among various teacher educators or different teacher preparation programs. Do certain programs make "better" use of technology and ultimately prepare teachers who are "more effective" computer users? Ethnographic methodology provides an excellent way to identify and highlight exemplary programs or "innovative" users of technology and to share this information with others. It also provides a way to identify programs which are successful in integrating technology into the overall teacher preparation process. This type of information can be used by other programs to guide their development and implementation of technology integration plans.

While there are clearly many issues related to technology use and teacher education that can be effectively investigated through the use of

ethnographic methods, there are other questions which may be better suited to alternative research methods. For instance, studying the impact of computer use on students' achievement levels or on their time on task may be more successfully examined with quantitative means. Further, issues of computer access or the effect of computer use on learners' academic performance may also be better suited to non-ethnographic methods.

A Specific Example of Ethnographic Research Informing Teacher Education

In a recent study, Novak (1991) used ethnographic methods to explore the instructional computer use of first-year elementary classroom teachers. This research effort was targeted at better understanding first-year teachers, computer-using teachers, and the interaction of the two.

There is strong evidence to suggest that beginning teachers are highly influenced by their classroom contexts (Doyle, 1979) and as beginning teachers gain comfort in these contexts and in their new professional roles, they typically develop a set of routines which moderate behavioral patterns within the classroom and evolve into a "culture." Often the routines which are developed early in teachers' careers impact their teaching for the remainder of their teaching careers (Bullough, 1989; Ryan, 1986; Veenman, 1984). That is, the type of classroom culture which they create in their early years as a teacher will be remarkably similar to that which they create in classrooms later in their careers. Given this information, Novak (1991) sought to explore how beginning teachers adapted to the culture of teaching and created their own classroom cultures by using computer use as the lens for viewing these processes.

In this particular study, six beginning elementary teachers from southeastern Michigan, recommended by their school administrators as possessing specific or unique computer knowledge and skills, were selected as the informants. By chance, these teachers were all female and taught in grades two, four, and five in middle-class school districts. The exploration of computer use by these teachers was conducted during the second semester of their first year of teaching to allow time for them to settle into their new professional roles, to develop a pattern of computer use, and to create a classroom culture.

The data collection for this research endeavor was built on ethnographic methods: in-depth interviews; classroom observations; informal conversations; and written documents, namely daily logs maintained by the teachers. Initially, an in-depth, open-ended interview was conducted with each teacher to develop a sense of her background,

beliefs, and experiences. At the end of the interviews, the teachers were asked to maintain written logs for a two-week period outlining their uses of the computer and reflections about these uses. The interviews were audio recorded and immediately transcribed. Using a constant comparative method of analysis as described by Glaser and Strauss (1967), initial analyses were made, questions generated, and interpretations developed. Questions which emerged from this initial analysis were explored through informal discussions with the teachers, and themes were verified through classroom observations, further conversations, and the written documents.

Although it was impossible for the researcher to become a true participant of the classrooms under investigation due to the nature of elementary classroom environments, Novak spent several days in each classroom and developed a strong rapport with the teachers and many of the students, often interacting with the teachers and students during instructional activities, particularly those activities making use of the computer. The observations, which were conducted throughout March, April, and May, provided opportunities to actually see the teachers in action, both when they were using the computer and when they were not. The analysis of the observational data identified new themes and also verified existing ones. Near the end of the observations, composite profiles of the teachers were written based on the data which had been collected and analyzed. These profiles were intended to provide insight into the individual characteristics of each teacher, to describe a typical day of teaching for her, and to highlight the ways she used computers and the influences on these uses. The composite profiles were shared with the teachers, and they were asked to corroborate the findings revealed in them. The teachers overwhelmingly felt that the profiles captured their essence and accurately reflected their situations.

The findings of this study suggest that computer use among these beginning teachers was influenced by a variety of factors, including their personal beliefs about the importance of computer experiences for their students, their difficulties in managing one computer for a classroom of students, their perceptions of limited time to learn about and use the computer given other teaching responsibilities, and by their knowledge of available software. These findings support the notion that future and beginning teachers need instruction in and support for the use of computers in their classroom instruction. Teacher educators would do well to model the use of computers in instruction to provide examples upon which future teachers can build. Further, future teachers can benefit from teacher preparation activities which provide hands-on, field-based experiences with computers to develop realistic expectations and ideas for using the computer in their subsequent teaching.

Strengths and Limitations for Use of Ethnographic Methods in Technology and Teacher Education

Ethnographic research has great potential for examining issues related to technology use and teacher education, such as the evaluation of instructional programs and the exploration of innovative uses of technology. Educational researchers will undoubtedly employ this method with increasing frequency in future research efforts because of its ability to examine and understand a complex situation from the perspective of the individuals involved. Further, this method promotes a holistic view of a research issue including the identification and exploration of all possible aspects and components rather than simply the investigation of those predetermined to be important. This, along with the inductive analysis process which is central to this method, allows for unexpected or even serendipitous findings to evolve.

There are, however, several difficulties associated with the ethnographic method. One of the greatest hindrances to conducting ethnographic research is the vast amount of time required in the field to collect the data. A related concern is that the intensive data collection produces sheer mountains of raw data which must be organized, analyzed, and interpreted. This makes the data collection and analysis process a time-consuming and labor-intensive activity for the researcher, often requiring months or even years of commitment to the research effort. As pointed out earlier, another difficulty associated with this type of research is the researcher's subjectivity and bias. Although these personal involvements can enhance the research process by building on the researcher's interest and insight, they can also detract from the objectivity and credibility of a study if the researcher is close-minded or allows personal biases to slant observations or interpretations by consciously or unconsciously ignoring important evidence. A final limitation of the ethnographic method is the difficulty in replicating a study. Generally, however, ethnographic studies are intended as an examination of a specific situation, often a unique situation, so there is little opportunity or concern for replication.

Despite limitations, ethnographic research methods provide researchers with an important set of techniques for investigating the timely and important issues related to technology use and teacher education. They provide ways to get inside classrooms and into teachers' minds to better understand the impact which technology use has on them as individuals and on the classroom cultures which they create.

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Systematic Classroom Observations of Technology Use

Juanita V. Copley and Susan E. Williams

Observation can be described as a "deliberate, systematic, question-specific, conscious process" (Evertson & Green, 1986, p. 163), a technique that can produce characteristically rich, detailed descriptions of instructional events (Berliner, 1986), or a means of representing the reality of the classroom (Evertson & Green, 1986). The diverse descriptions provided by the collection and analysis of classroom observations potentially could lead to improved understanding of problems from a variety of perspectives and the testing of alternative solutions to problems for both researchers and practioners. To specifically examine the use of systematic observations in classrooms using technology, three topics will be highlighted. First, the observation process when used for the purposes of research will be discussed along with the hypothesized benefits. Second, the current status of observation methods used to conduct research in classrooms teaching with technology will be illustrated. Finally, the strengths and limitations of observational techniques and proposed implementations of their use in teacher education and technology will be examined.

The Observation Process

The fundamental purpose of classroom observation is to generate and test plausible theory concerning teaching. Based on the specific purposes of the research, decisions must be made regarding the procedures involved in collecting data, the instrumentations used for that collection, and the types of analyses that will be utilized. Operational

definitions, training methods for observers, foci and settings for observations, schedules and time frames, recording methods, and procedures used to process and analyze data are all important considerations in the observation process (Stallings & Mohlman, 1988).

The types of observational systems include category, descriptive, narrative, and technical records. Category systems, closed with preset categories, focus on behavior in general and most commonly use checklists or rating scales. Both descriptive and narrative systems are open systems and primarily differ by their recording methods of transcriptions of selected behaviors or broad segments of events, respectively. Since the early eighties, videotape and audio recordings have been used to form a technical record in combination with other types of systems. Since the coding of videotape observations is far easier than in-class coding, a high level of interobserver reliability and the potential for validity can be raised with the use of technical records (Leinhardt, 1988).

The tools used to collect observational data include checklists, rating scales, narrative descriptions, and interactive coding systems. Checklists with their discrete categories make observers' training and data analysis fairly inexpensive; however, the data collected does not provide information about the continuous processes that occur in the classroom. Rating scales, on the other hand, allow the observer to assess high-inference variables, but inherently introduce more subjectivity into the process. Narrative descriptions involve short training periods and result in especially rich descriptions of the classroom. The processing of the data, however, is extremely time-consuming and costly. Interactive coding systems are generally objective systems in which the observer rates frequencies of interactions using specific categories. The training period is quite involved and often the content of the lesson or the quality of the interaction is neglected. Again, depending on the purposes of the specific research, combinations of these four tools are often used (Stallings & Mohlman, 1988).

Systematic classroom observations can improve research by providing (a) a view of the continuous decision-making by both students and teachers that occurs in classrooms, (b) a rich descriptive basis with sufficient detail to form decisions regarding further research or the evaluation of current research, and (c) better studies of classroom learning and instruction (Clark & Peterson, 1986; Dwyer, 1991; Grouws, 1991). In an attempt to capture the essence of the classroom, observational methodology involves the use of trained observers and/or videotape technology, thus producing a great ecological validity to research results (Hiebert & Wearne, 1991). Specifically, this methodology forces researchers to focus on the processes involved in teaching and learning and on the way that classroom events fit together to form meaningful

learning. When observational techniques are used in collaboration with other forms of data collection, product measures are meshed with the often complicated processes that occur during instruction. Conversely, with little or no observational data, researchers may simplify complex problems and classify results as caused by simple interventions rather than producing a more realistic, complete view (Hiebert & Wearne, 1991). When observational data are synthesized with other research approaches, the result is a more thorough understanding of the causes, conduct, and consequences of teaching.

Use of Systematic Classroom Observation in Teacher Education and Technology

Currently, educational reforms in the areas of teacher education and technology have generally been researched using self-report, interview, and survey methods of data collection (Swadener & Jarrett, 1986; Woodrow, 1987); the benefits of classroom observations have not been fully utilized. Most often, research regarding technology and teacher education emphasizes the quantity of the use of technology in instruction and learning rather than the quality of that use. Researchers have counted the number of computers in a system, calculated the time allotments for student use of technology, and investigated the availability of technology to students. For example, researchers found that in 1988, 1.7 million computers were available for use in public school and 90% of all schools in the United States had VCRs (Glenn & Carrier, 1989). During the 1984-85 school year, about 500,000 teachers used computers with 15 million students in American instructional programs (Baird, 1989). These statistics are the results of just a few of the studies whose focus was primarily on the quantity of technology available to teachers and students. Additionally, hundreds of studies have been conducted which used pre- and postachievement and attitudinal measures coupled with a variety of technological interventions. These product-oriented studies examining the use of technology in classrooms typically employed large amounts of relatively obtainable, self-report survey data.

When conducting research regarding the quantity and quality of technology use and instruction in classrooms, however, the collection of observational data seems to be necessary. According to some researchers (e.g., Glenn & Carrier, 1989), the integration of computers and other types of technology with subject matter and classroom activity is one of the least well addressed issues in the teacher education community. Observational data would seem to be required if this deficit is to be corrected.

Many studies have effectively used technology (e.g., videotape, tape recorders, cameras) to collect observational data from classrooms

(Cognition and Technology Group at Vanderbilt, 1990; Hoover, Mines, & Gagnon, 1991), but few studies have used observational data to research the use of technology in the classroom. One of the earliest exceptions was Goodlad (1984). In his extensive study of schooling, his observers "found little use of calculators, computers." Consequently, Goodlad concluded that the "technological revolution leaves schools virtually untouched" (pg. 340).

In another early study, Shavelson, Winkler, Stasz, Feibel, Robyn, and Shaha (1984) used systematic classroom observations in conjunction with teacher and administrator interviews. After selecting 60 teachers from 25 districts and 49 schools based on their nomination as "successful users of microcomputer-based mathematics and science instruction, researchers observed one class period for 50-minute segments per teacher. The systematic observation method used required researchers to map the physical layout of the room, identify activity structures in the classroom, time the amount of computer activity, and select and observe several students using software. Several checklists and rating scales were used. Collating the observation data along with data collected from the interview, four clusters for effective microcomputer use were identified: (a) orchestration and management, (b) enrichment, (c) adjunct instruction, and (d) drill and practice activities. In addition, and perhaps more importantly, researchers concluded that, due to the observational data, they found good reason for concern regarding social inequalities in computer-based instruction and lack of good instruction involving technology.

Merino, Legarreta, Coughran, and Hoskins (1990) examined the interaction at computers by language minority boys and girls paired with fluent English proficient peers involved in videotaped observations. Interactions, on or off-task behaviors, and degrees of success were coded using a specially developed questionnaire. They found that regardless of gender, the pairing of students using technology can be an effective strategy for computer instruction in bilingual programs.

Kinzer, Littlefield, Delclos, and Bransford (1985) observed two fifth-grade classes to determine the relationship between engagement and learning in different Logo learning environments and mastery. The observational system that they used, the Stallings Observation System (SOS) (Stallings, 1983), required that three independent observers observe a class three times during data collection. Categories of behaviors classified teacher and student interactions along with the time allotments. They found that there were no observable differences between the two Logo environments and concluded that the "quality of specific activities involving the microcomputer was not assessed with the traditional observations measure used" (p. 42). They further stated that to study the degree to which students use microcomputers, new observational instruments would be required.

Koontz (1991) investigated gender equity and technology use in middle school physical science classes using a combination of videotaped observations, interviews, and pre- and postachievement tests. Using an interactive coding system, the videotaped observations were analyzed for the frequency of gender-fair practices; namely, equal questioning of both males and females, ratio of asking girls to boys to use the computer, ratio of girls to boys being asked to set up and perform experiments, use of cooperative learning with equitably assigned roles, and the use of role models. Primarily because of the observational data collected, the results showed that teachers did not demonstrate fair equity practices in the use of technology, even though they were aware of those practices. In the analyzed observations, boys were always assigned the more technical roles when teachers selected a student to demonstrate a concept using the computer technology.

Carey (1991) compared the teacher behaviors in computing environments and regular classrooms. Using a Timeline Coding technique (Acheson & Gall, 1980), observers tallied the types of behaviors that occurred in both environments and then calculated the proportions of time spent during the observed class in each behavior category. The hypothesis that no significant difference existed between the computer-augmented or regular environments was supported by the results of this study.

Prokosch, Bright, and Freiberg (1991) used systematic classroom observation instruments to determine how technology (both calculators and computers) were being used to teach mathematics. Categories included on the form were teacher instructional activity, technology being used, grouping patterns, knowledge level of content, and off-task behaviors. It was found that students were on task an average of 97% of the time, independent of the type of technology being used. In addition, computer students were observed to be on task significantly more often than calculator students.

The use of calculator technology has been a frequent focus in the research area of mathematics instruction. Often, when the effects of calculator usage are only reported from self-reported survey instruments, standardized tests, and attitudinal instruments, conflicting or non-conclusive results occur. A 3-year study examining the quality and quantity of calculator use of 7,000 middle-school students is currently in progress. As part of the data collection, 60 teachers are being observed systematically in four class periods per year. This observation data in collaboration with other achievement and attitudinal measures should provide some clarifying information regarding the use of calculator technology (Copley, Williams, & Huang, 1992). Clearly, systematic observational data coupled with other measures would aid the understanding of calculator use in classrooms. From a broader perspective,

the success of mathematics programs (a content area where the use of technology is most often encouraged) needs to be evaluated by a wider range of measures than conventional testing (Hill, 1980).

Strengths and Limitations of Observational Research

The strengths of observational research seem to be particularly applicable to research on the use of technology in classrooms. One important strength of observational methodology is that the process allows the research to integrate multiple perspectives into a single project. Thus, the analysis of the results can identify a problem from many different viewpoints and possibly view the situation as a composite of complex ideas (Evertson & Green, 1986). The newly developing field of technology and teacher education needs the rich information and detail that is generated from the use of observational methodology to develop the necessary theory and models for the integration of technology and the area of curriculum and instruction. Perhaps, many of the conflicting results regarding technology and teacher education could be resolved with the addition of observational data.

Another strength involves the type of research that can be generated using observational methodology. It is easy to view the superficial changes (number of computers or other kinds of technology, classroom organization, for example) that technology affords without the use of systematic classroom observations. However, the more important questions of how learning and teaching are changed because of technology can only be discovered when systematic classroom observations are conducted in conjunction with other forms of research. Finally, another strength of the use of systematic classroom observations is inherent in the methodology itself. If correctly designed, the instruments used for observations contain questions or scales identified in advance so that a systematic approach is a necessary component to the observational process. The observation instruments should be the products of previous exploratory work and aid in the careful collection of detailed, often overlooked information.

One of the most obvious limitations of systematic classroom observations is the time-consuming nature of such research. Since the data must be collected, transcribed, coded, and analyzed, observational data in classrooms is expensive and labor-intensive. Funding and the time that is necessary for the collection of observational data is often not available for the studies contemplated and as a result, the sample sizes are usually small. Small sample sizes, particularly in research involving technology and teacher education, cause problems with observational research. If the sample can be selected to effectively represent events to be studied, the small sample size can be acceptable. However, in

technology and teacher education, it is not always clear what kind or type of technology is representative of the larger population or what use of technology in education is most representative.

A second limitation of observation data is that the findings from classroom observations can never stand alone. While extensive by their very nature, all observations must be viewed and interpreted through the eyes of theory to gain significance (Evertson & Green, 1986). Since the field of technology as used in teacher education has few models or theoretical frameworks, often observational data are collected in a seemingly haphazard manner without consistent, theory-based criteria.

Finally, since observational data produce rich detail, often reports of the results of such data are not described sufficiently. In an effort to be concise and still make sense of the observations, researchers often report insufficient data to make the reported interpretations; external, contributing factors are ignored. Care must be exercised in the interpretation of such data along with a careful reporting of the observations conducted so that the results are not seen as being based solely on observers' impressions.

Proposed Implementation

The use of observational methodology could clearly add to the research base of teacher education and technology. Despite the emphasis on the importance of technology in many content areas, little evidence exists to suggest that change has occurred in classrooms. Specifically, technology seems to have limited effect on the organization of classrooms and the implementation of innovative methods proposed in the research (Becker, 1986; Day, 1987). Changes in instructional uses of technology have clearly been proposed; however, evidence needs to be collected which would support those changes and research effective methods of implementation. If the methods and circumstances that promote change in the use of technology were to be researched, observational data would be an essential component to the change process (Good & Biddle, 1988).

Secondly, it is important that we are doing research on actual events and not on nonevents. If we are studying the integration of technology in the classroom, we need to know if in fact technology is being integrated into the classroom. That cannot be evaluated unless observations of classroom events are actually made. If data were collected to the exclusion of systematic observations, we could be evaluating the nonintegration of technology into classrooms rather than the integration of technology (Dwyer, 1991).

Vanderbilt University is currently using technology to make systematic classroom observations of both novice and expert teachers

(Vanderbilt Cognition & Technology Group, 1990). The tapes that are generated are then placed on interactive video systems and used by beginning teachers to make decisions regarding instruction and curriculum. Although not currently practiced, the methods used by the Vanderbilt University studies could certainly be used to observe the use of technology in classrooms. Beginning teachers involved in preservice or inservice training could then see technology as it is used in the classroom and thus prepare for their future use (Goldman & Barron, 1990). In addition, research supports the fact that teachers need to perceive an innovation as a solution to an existing problem to incorporate a change into their instruction (Cuban, 1986). Systematic classroom observations of technology use using videotapes and developed as interactive modules for teacher education programs might offer a partial solution to the integration of technology into teacher education. If teachers could see expert and novice teachers use technology effectively, the first step toward change may occur.

Other kinds of research involving teacher education and technology use seem to be especially appropriate for observational techniques. Interactive coding systems need to be used to assess the relationship between teachers' presentations, students' attention, and technology use. Continued comparisons between expert and novice teachers who use technology effectively in their classrooms need to be conducted from a variety of perspectives. The effectiveness of the use of technology to the development of particular concepts in content areas along with the instructional methods necessary to aid that development require investigation. Systematic classroom observations of technology could produce some important insights to teacher education and technology; its use needs to be expanded.

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The Future of Research on Technology and Teacher Education

George W. Bright and Hersholt C. Waxman

It is clear from reading the chapters in this monograph that there is still much to learn about technology and teacher education. As with the study of technology in most areas, there are three ways that technology can be used. First, technology can be used to teach teachers about technology. Second, technology can be used to improve the delivery of current teacher education programs. Third, technology can be used to restructure teacher education or do teacher education differently. We will argue that it is the third of these ways that deserves most of our attention.

Teaching About Technology

As Cleborne Maddux argues, the study of the instructional benefits of computers has gone through several stages. Hopefully, our current stage of investigation will lead us to clearer understanding of both the benefits and limitations of use of technology, not only in learning content but also in learning about teaching. Similarly, Gregg Brownell points out that much still needs to be known about the state of technology use in classrooms (both K-12 and teacher education classrooms), but we equally need to investigate how the power of technology lets us learn about how to become a teacher in new and unusual ways.

For the foreseeable future, there will continue to be a need for exposing preservice and inservice teachers to technologies; indeed, new technologies will constantly emerge that need to be introduced to teachers. But we need to shift our research focus away from mere

exposure and toward changing the face of teacher education to take account of the fact that technology has absolutely changed the world of teachers and students. We need to learn how to best take advantage of the power that technology offers us to behave differently.

For example, the effective schools research of the 1980s (e.g., Good & Brophy, 1986; Purkey & Smith, 1983; Wimpelberg, Teddlie, & Stringfield, 1989) was based on the assumption that effective instruction was that instruction which produced the greatest gains in standardized tests. The objectives of those tests were typically weighted toward relatively low-level content (e.g., recognition of examples, computational procedures, definitions, etc.) rather than problem-solving aspects of the content. Effective schools research then helped identify characteristics of teachers who were effective at improving the test scores of their students; for example, teachers who managed highly structured classrooms in which the flow in information was mainly from the teacher to the students. The current reform movement in mathematics education is projecting a vastly different set of outcomes for mathematics instruction, for example, outcomes that emphasize creative problem-solving performance. Technology is virtually essential for such performance, but it seems unlikely that highly structured classrooms with one-directional flow of information will be the best places for students to take advantage of the power of technology to develop their problem-solving abilities. Analogously, teacher education programs in which professors "lecture at" students are unlikely to be the best environments for helping prospective teachers develop appropriate teaching repertoires. We need to learn how to use technology to create different kinds of teacher education programs that produce different kinds of teachers.

Delivery of Current Teacher Education Programs

Some attention has been given to use of technology to deliver "standard" chunks of teacher education programs; for example, computer simulations for teaching classroom management (e.g., Strang, Vekari, & Tankersley, 1991) and videotaping in clinical experiences (e.g., Perlberg, 1987). There is some evidence that technology might provide more efficient delivery systems for these chunks. More research needs to be done, and ethnographic and experimental methods seem especially useful for studying these questions. The development strategy for such uses of technologies, as outlined by Jerry Willis, needs to parallel and complement this research.

It seems likely that school environments will change slowly, so standard teacher education programs will continue to provide teachers with useful information about teaching. Meta-analyses of collections of such studies would help identify the effectiveness of technology in these

settings. In particular, as Yuen-Kuang Liao and George Bright point out, meta-analyses indicate that computers improve the learning of cognitive skills, with smaller effects for meta-cognitive skills. Are teacher education skills more often cognitive or meta-cognitive (or something else, like affective)? Examining meta-analyses of studies of the use of technology to improve various kinds of skills might reveal patterns that would suggest which parts of teacher education programs might be most directly impacted by technology. This knowledge would impact both research and development.

In a related vein, Juanita Copley and Susan Williams point out the need to investigate the uses of technology by expert and novice teachers. Equally important, however, might be the comparison of expert teachers and expert teacher educators to determine similarities and differences in their uses of technology. Content analyses of K-12 computer software and teacher education software would be a desirable complement to such comparisons.

We also need to keep clear records of the progress of integrating technology into teacher education programs. Systematic surveys seem to be one way to do this, but they cannot be conducted without long-term institutional support. Parallel content analysis studies would be needed to monitor the development of appropriate materials support for changes in teacher education programs. As Dianne Novak points out, using technology in teaching is an enormously complex task. The effects of modeling by teacher educators on both novice and experienced teachers need careful study and documentation.

Changing Teacher Education Programs

In the longer term, however, technology seems likely to change the whole process of teaching. For example, technology (e.g., graphing calculators) is providing mathematics students with more control over the problems that are investigated and the processes that are used to make those investigations. That is, students themselves play a larger role in determining the content that is studied. Richard Johnson also points to the changes in autonomy that learners have in technology environments.

How will technology increase the autonomy of prospective teachers? Will technology help them to make decisions about what they learn, when the learning takes place, and in what mode the information is retrieved to be learned? Will technology alter the ways that prospective teachers demonstrate that they have learned? For example, will prospective teachers be able to make interactive video "shows" that demonstrate their skill at managing a classroom? Will electronic communication allow them to discuss what they have learned with "real"

teachers as a means of validating that learning? We need research on a wide variety of uses of technologies as a means of empowering prospective teachers to take control of their learning. We have, probably for too long, relied on the perceptions of professors and cooperating teachers as the standards for the quality of teacher education graduates. Technology may allow those graduates to demonstrate their learning in significantly more reliable ways.

How can technology help prepare teachers for new environments in which technology has a more prominent place? We need research on innovative teacher education programs that are tied to innovative schools in which technology plays a much more prominent role. Because these programs would be expensive to operate, there would not be large numbers of them, so ethnographic or classroom observation techniques might be the most appropriate ways to document the effects of the teacher education programs, with experimental techniques used to compare the effectiveness of the graduates of these programs in helping students learn.

As several authors point out, technology involves many things other than computers. Calculators, videodiscs, videotapes, and audiotapes are just a few of the technologies that need to be investigated. Computers may be the "latest and greatest" technology, but there are many situations which do not require such sophisticated enhancement. We need to use the most appropriate technologies, not just the most sophisticated.

Future Directions in the Study of Technology and Teacher Education

There are several areas in the study of technology and teacher education that hold promise for improving education. One area, for example, that is receiving a great deal of attention is the use of technologically enriched professional development schools. Professional development schools have been found to be effective sites for improving staff development and preparing teachers (Goodlad, 1991; Stallings & Kowalski, 1990). Some of these innovative schools, however, are now becoming "technologically enriched." These technologically enriched schools and classrooms contain "state-of-the-art" technology, and involve preservice teachers, classroom teachers, and university personnel. These schools have the potential to change teacher education programs as we now know them, because the programs will become much more school-based and allow teachers, preservice teachers, administrators, and university personnel to interact through sophisticated computer networks. In addition, Kip Tellez describes how technologically enriched teacher education classrooms in universities can change

instruction in teacher education programs and similarly change teacher education. Research on the effects of these types of innovations are critical, if we are going to argue that technology can restructure or change teacher education. Another aspect that is especially promising is "teacher as researcher" or "survey feedback" projects. In "teacher as researcher" projects, teachers engage in the research process by trying out new techniques and systematically assess their effectiveness (Elliott, 1987; Kelsay, 1991). In "survey feedback" projects, teachers receive systematic feedback or classroom profiles from their own class(es) related to technology use and consequently change their classroom instruction or learning environment. Several studies and reviews have found that teachers can improve their classroom instruction by receiving such feedback and then through reflection and/or discussion and intervention improve their instructional and classroom learning environment (Duschl & Waxman, 1991; Fraser & Fisher, 1986; Fraser, Seddon, & Eagleson, 1982; Fraser & Tobin, 1991). These approaches may be especially important in the field of technology and teacher education because teachers need to initially examine their own beliefs and practices before they will make major changes in their own teaching (Dwyer, Ringstaff, & Sandholtz, 1991). Furthermore, the notion of the "experimenting classroom" is another concept that can be appropriately applied to these approaches because it suggests that we need to constantly try new approaches in the classroom in order to continually grow and improve our teaching.

Another area that may change research in the field and improve education is the use of newer and better analytic techniques. Some techniques such as causal modeling, for example, have been widely used in education, but there have been few applications in the field of technology and teacher education. Causal modeling techniques such as LISREL have promise because they address the issues of measurement as well as examining the structural relationships among variables (Hayduk, 1987; Loehlin, 1987). Furthermore, such causal modeling techniques force researchers to develop theories or models of how technology influences teacher attitudes and behaviors or how technology impacts student learning, attitudes, and achievement. Similarly, other techniques such as hierarchical linear models (HLM) hold promise because they allow researchers to investigate hypotheses about the effects of within- and between-school or class factors on variables such as teachers' or students' attitudes and use of technology as well as the impact of various training or staff development models (Bryk & Raudenbush, 1989; Raudenbush & Bryk, 1989; Raudenbush & Willms, 1991; Rowan, Raudenbush, & Kang, 1991). These new analytic procedures may allow us to conceptualize the research on technology and teacher education differently and thus develop new ways of thinking about educational phenomena.

There have been several exemplary programs of research in the field of technology and teacher education, but more programmatic research is needed. Although the federally funded national research center on technology has recently been eliminated, there are still several other excellent R&D Centers that continue to exist and be funded with federal, state, and corporate or foundation monies [e.g., Texas Center for Educational Technology (Brumbaugh, Poirot, & Beckman, 1991); Vanderbilt University Center on Technology and Cognition (Cognition and Technology Group at Vanderbilt, 1990, 1992)]. Professional organizations in the area of technology such as STATE may similarly facilitate programmatic research through its conference, journal, and monograph series. Teacher education organizations like the Association of Teacher Educators and the American Association of Colleges for Teacher Educators can also encourage concerted research efforts.

Although some of the research summarized by the articles in the present monograph suggest several consistent relationships between technology and teacher and student outcomes, further descriptive, correlational, longitudinal, and especially experimental research is needed to verify these results. In addition, studies should attempt to replicate some of the previous studies in other settings, especially in inner-city settings where many more students are at risk of dropping out and not furthering their education, and teachers are also considered to be working in at-risk school environments (Waxman, 1992). These and other issues still need to be examined so that we can continue to understand how technology influences teacher and student outcomes, as well as how technology can change teacher education.

Today's world is a mix of good news and bad news. The good news is that technology seems likely to revitalize the process of teacher education more than any other change in the history of teacher education. There will be opportunities to improve that would not be available if technology were not driving the changes. The bad news is that technology is changing so rapidly that once we think we understand important relationships between the use of technology and the quality of the teachers and teaching, the technology will have changed dramatically. We will be back in the position of needing to do additional research to understand new relationships. Research takes time to plan, conduct, and evaluate. But the technology that is the focus of that research will continue to change, and the relationships we establish for one type of technology may not transfer to new technologies.

One possible response to this state of affairs is to become overwhelmed at the prospect of never reaching the end of the quest. However, the energy and enthusiasm of the people who have contributed to this volume are certain to act as an antidote to the lethargy that tends to result from feelings of being overwhelmed. Understanding the

role of technology in teacher education is a an enormous challenge. But we believe that our colleagues are not only qualified to meet that challenge but also dedicated to making technology serve the purpose of improving instruction in our nations' schools.

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